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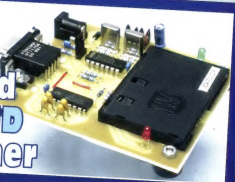

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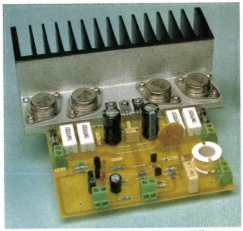

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Publisher & Editor-in-Chief
Leo Simpson, B.Bus., FAICD

Production Manager
Greg Swain, B.Sc.(Hons.)

Technical Staff
John Clarke, B.E.(Elec.)
Peter Smith
Ross Tester
Jim Rowe, B.A., B.Sc, VK2ZLO
Rick Walters

Reader Services
Ann Jenkinson

Advertising Enquiries
Leo Simpson
Phone (02) 9979 5644
Fax (02) 9979 6503

Regular Contributors
Brendan Akhurst
Rodney Champness, VK3UG
Julian Edgar, Dip.T.(Sec.), B.Ed
Mike Sheriff, B.Sc, VK2YFK
Philip Watson, MIREE, VK2ZPW
Bob Young

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Editorial & advertising offices:
Unit 8, 101 Darley St,
Mona Vale, NSW 2103.
Postal address: PO Box 139,
Collaroy Beach, NSW 2097.
Phone (02) 9979 5644.
Fax (02) 9979 6503.
E-mail: silchip@siliconchip.com.au

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PUBLISHER'S LETTER

Queensland TV repairs now need an electrical licence

Yep, the Queensland Government, via its union-dominated Electrical Safety Office, has been at it again. With its new Electrical Safety Act, commencing on October 1st, 2002, any business doing repairs on electronic or electrical appliances now needs an electrical contractor's licence. Previously, this requirement only applied to those doing electrical installation work but now, after the farcical electrical safety review at the beginning of 2002, the vise is tightening.

So if you are in a business in Queensland doing any sort of electronic or electrical appliance repairs, you now need an electrical contractor's licence. The fact that you are more highly skilled than any electrician cuts no ice – you now need an electrical contractor's licence; end of story. This is supposedly all in the interest of reducing death from contact with electricity but as anyone who knows the true situation can attest, most people who die in Queensland from electrocution are either electricians or trades people working on construction sites.

No doubt there will be plenty of people who will bleat about this new licence requirement but we gave heaps of warning about this nonsense when we had our long and ultimately futile campaign about do-it-yourself electrical wiring. I cannot believe that the affected various trade organisations, engineers and businesses have allowed this legislation to be enacted. They have been utterly supine. Well, the reward for apathy is more government regulation and since there are Labor governments in every Australian state, this nonsense will probably spread throughout the country.

The requirement for businesses to have an electrical contractor's licence takes effect from 1st February 2003. Furthermore, "If an applicant cannot complete the necessary competency for the business component (public service speak for shutting you out), an application will be accepted so long as the applicant provides a certificate of attainment within six months of obtaining their licence and before 1st August 2003". If you want to read more of this mindless bureaucratic drivel, go to the website **www.eso.qld.gov.au**

The net result of this stupidity will not be an improvement in the death rate from electrocution in Queensland. But as always happens when government becomes intrusive, there will be lots of unintended consequences and ordinary people will be worse off. Many small electrical and electronic repair businesses in Queensland will close. There is not a shadow of doubt about this. These small businesses already have enough burdens without having to try and satisfy this unnecessary regulation. Many who have been soldiering on for years will now close up and take retirement. Can you blame them?

Even larger repair businesses that do warranty work on new appliances will look askance at this new requirement. I would not be surprised if some of these decide to give up as well.

So not only will Queenslanders not be able to get their TV, PC, fax machine or other electronic gear fixed, they won't get their washing machine, dryer, stove, vacuum cleaner or other appliances fixed either. Good result, eh? Far more repairable appliances will end up on the tip. And how much hardship will be caused to those who can ill-afford to buy replacement appliances. Of course, those few Queenslanders who do manage to find a repairer in the future will sleep much more soundly because their appliance was fixed by a "licenced electrical contractor". Won't that be nice?

Is there any hope? Well, we do still live in a democracy (sort of). If the affected business organisations get off their behinds and really lobby the government, this nonsense could be overturned. But I'm not hopeful. Happy New Year.

Leo Simpson

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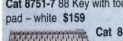
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MAILBAG

Internet Sharing with Linux and WiFi security

After all these years, you guys still are the best! Seriously though, I loved the article about WiFi in the November 2002 issue and intend to try setting up a test link P2P between my house and my brother's sometime soon. However, I am concerned that the writer is understating the risks involved in running wireless with standard security. It is widely accepted within the IT industry now that 802.11b and WEP offer little practical security for the modern business.

So serious is the issue that companies like Cisco systems are now selling their wireless products with "temporary" additional security measures to enhance the defaults until a suitable new standard is finally settled upon. I feel that security issues need a better airing, perhaps in a future issue of SILICON CHIP.

I also loved the article in November 2002 about using a Linux box for sharing a cable modem. This is something I haven't tried yet. I thought, however, that you may want to have a look at a ready built Linux based firewall/sharing software kit. I have been playing with and actively promoting (to anyone who will listen) the IPcop firewall project for the last six months or so. IPcop is a spinoff of the early GPL code used in the now commercial Smoothwall firewall.

The IPcop team have made significant changes to the original code over recent months and are now close to releasing their second revision (0.1.2). What makes these firewalls stand out is that the system installs via a self-booting CD (supplied as an ISO image), formatting and setting up any suitably fitted old PC as the gateway machine. The build asks a few simple questions to establish its interfaces for the trusted network, DMZ and Internet, etc, and then after the first reboot is fully managed via a Web browser on the internal network. No more editing lots of config files!

IPcop is free software as for most Linux distributions and the development team are friendly and engaging to all the folk who use the system.

I have had one running for six months or so now and have set up a few for friends who use ADSL. The firewall is easy to manage, reliable and even lends itself to modifications and tweaks via the SSH remote access for adding extra features.

Have a look at **www.ipcop.org** for more information.

Ray Ellison,
Adelaide, SA.

Comment: We agree that wireless security (or lack of it) is a big issue.

Thanks for the Linux articles

A big thank you for the articles on Linux. I would like to see more, especially for those of us who use ADSL.

I have tried to use Linux for some time now but get so frustrated because no one has easy to read help (in plain English) until you started to print some. I have been an avid reader of SILICON CHIP for years and sweat on the copy to arrive each month in the post. Keep up the good and informative work.

Robert Carnes,
via email.

Subwoofer saga with an ETI-480 amplifier

I have been meaning to write for some time and congratulate you on an excellent magazine. I have an extensive library of every EA since 1965, every ETI and almost every SC (just missed a few of the early ones).

I find that SC projects are of the highest standard and this was brought home recently when I decided to build a self-powered subwoofer for a recently purchased DVD player. I obtained a suitable speaker and made a substantial box based on its Thiele & Small parameters and various designs published on the Internet.

I just happened to have a half-finished ETI480 amp and power supply lying around so thought this would be suitable. I finished off the amp and installed it along with a kit sub-bass processor purchased from Dick Smith Electronics, based on the design in EA September 1999. When finished, I initially connected the new subwoofer to my existing stereo and was amazed at how bad it sounded on some program material.

To cut a long story short, I made literally dozens of changes to the internal bracing of the box, the power supply, the sub-bass processor and finally, the ETI-480 itself and although I improved the sound somewhat there was still distortion and instability on certain low-level tracks.

I had almost given up and decided to buy a commercial unit when I read your article on the problems school students were having with the ETI-480. I knew as soon as I read it that the power amplifier was the problem so I raced down to my local Dick Smith store again and bought the last SC 50W amplifier module (based on the LM3876 and published in February 1994) and a power supply they had in stock. The subwoofer now sounds first class.

Tony Lohrey,
via email.

Cat.5 tester is a beaut

My thanks to Craig Stephen. His simple Cat.5 network tester on page 72 of the November 2002 Circuit Notebook is a beaut. I have wanted to build something like that for ages since I got a crimper and started making Cat.5 cables. It's a pain testing them with a multimeter. I found that the stop/step was really start/step, but whatever!

It cost about $15 for the parts; mostly $10 for a bag of 50 LEDs. I got a couple of microswitches out of a dead mouse and used an old token ring network cable converter for the remote assembly. I know you can buy the whole thing brand new from DSE ($90 on

special for November) but half the fun is building it out of old bits.

Ray Haverfield,
via email.

CD deterioration due to foam packing

I wonder if other readers have experienced the same problem of major deterioration of music CDs that I have had?

I am aware of the literature on CD "bronze" corrosion, after being guided to the appropriate website **http://personal.riverusers.com/~manderso/uhjdisc/bronzing.htm** However, my problem does not appear to be a bronzing of the disc. Rather it is "decay" of the silver (aluminium) reflective surface.

It happened on Disc 1 of a 2-CD set of the opera "La Boheme", from EMI. The last two tracks on the disc would not read and when I examined the disc, I found two holes in the reflective layer, about 2-3mm in diameter on the outer edge of the disc.

I also noticed that the label surface of the disc felt sticky and gritty, and realised that the foam plastic sheet often put in CD sets to hold the disc in place had rotted and bits of it had stuck to the label surface.

When I took Disc 2 out of its case, I found the foam plastic sheet stuck hard to the label side. I managed to remove it but the surface is still sticky and gritty, and when I hold this Disc up to the light, it appears to be peppered with thousands of tiny pin holes, which seem to correspond to the places where the foam plastic had stuck to the surface. Disc 2 plays but with jumps.

I now relate this to similar reflective layer breakdowns in two other single CDs which I also found with the foam plastic liner stuck to their label surface. I am dreading going through my entire collection of a couple of thousand CDs, wondering how many more might have been affected.

My CDs are stored in special shelves in a cool, dry room, with no direct sunlight and I believe my storage arrangements meet the general recommendation.

Since the literature on CD corrosion, dealing largely with discs pressed in Europe by Philips and Du Pont from 1998 to 1993, says the corrosion was caused by inappropriate inks and gels which attacked the disc itself, I am wondering if the rotting of the foam plastic could have released chemicals or corrosives which attached themselves to the disc surface and damaged it?

Incidentally, the La Boheme was a remaster from 1986 (outside the generally accepted time frame of faulty pressings) and was mastered by Nimbus. It does not have the "PDO" legend, around the centre-hole, which identifies the Philips-Du Pont pressings.

Not being a chemist, I don't know what reactions might occur between the foam and the surface of the disc but I imagine a breakdown of the foam is probably a chemical action and could well cause some kind of reaction. I am told the damage is irreparable.

In any event, I feel some exposure should be given to the fact that not all CDs are born equal and that, especially in the case of particular pressings from a specific time and place, deterioration is likely. People who have large collections might be wise to check discs which still have foam packed with them, and also to inform themselves of the bronze corrosion phenomenon.

We have been led to believe that CDs last for anything up to 100 or 200 years and are virtually indestructible. It appears, to the contrary, that they might be very mortal.

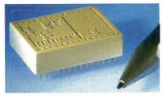
Knowing your propensity for taking up thorny issues, I can think of no better vehicle than your excellent magazine for informing people about this danger.

John Tingle MLC,
Parliament House, Sydney.

Comment: most plastic foams will be corrosive when they perish and break down, so the label is at risk. Most plastic foams will not last beyond 10-15 years in Australia – the heat does it. Even a slight scratch on the label can cause serious tracking problems. Our recommendation is to go through all your discs and root out any plastic foam packing. Nothing should be in contact with the label surface or the underside.

Apart from that, there could be a

The Tiger comes to Australia



The BASIC, Tiny and Economy Tigers are sold in Australia by JED, with W98/NT software and local single board systems.

Tigers are modules running true compiled multi-tasking BASIC in a 16/32 bit core, with typically 512K bytes of FLASH (program and data) memory and 32/128/512 K bytes of RAM. The **Tiny Tiger** has four, 10 bit analog ins, lots of digital I/O, two UARTs, SPI, I²C, 1-wire, RTC and has low cost W98/NT compile, debug and download software.

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wider consumer issue here, with record companies being obliged to replace faulty discs.

Amateur radio articles still wanted

I am just catching up with the last couple of issues of SILICON CHIP and would like to support G. J. Wilson of Tasmania, for his letter in Mailbag in the October 2002 issue. This is a wonderful opportunity you have at the moment to enrich your magazine with amateur radio articles.

Indeed since the demise of "Electronics Australia" and other radio magazines, all "radio-interested" people, including me, are left in limbo. Your magazine will definitely increase its readership by a fair bit if you were to grab this chance and present a much richer magazine with a much better variety of articles.

In the last few years, I stopped buying every issue of your magazine simply because it is getting more and more into computers.

In the recent AGM of the Australian Radio DX club, the general consensus was that everybody would buy your magazine if they found a few articles on amateur radio. And this club does have about 300 financial members.

I do hope my mild criticism will be very constructive,

Peter Theodorakis,
via email.

Comment: if you looked at SILICON CHIP over the last 10 years or more, you would not find any increased emphasis on computers – we've always covered them.

Publisher's letters endorsed

I have subscribed to SILICON CHIP since a trip to Oz in 1992. I also subscribe to "Everyday Practical Electronics" here in the UK. I completely disagree with your Mailbag subscriber Doug Thwaites and many of his comments in December's issue – particularly in reference to the Publisher's Letter.

I anxiously await the arrival of SILICON CHIP each month by airmail and it is read religiously in the following order:

(1). Publisher's letter.
(2). Mailbag.
(3). Ask Silicon Chip.
(4). Serviceman's Log.
(5). Jaycar and Dick Smith's adverts, mainly to compare them with things here in the UK.
(6). The rest – word by word!!

I am usually most disappointed if Leo Simpson writes solely on matters electronic! To me, his asides reflect the character of the man and I hope he does not change things. You will never please everyone but it's a good magazine pleasing 95% of its readers, I am sure.

G Wilsher,
via email.

Easy labelling method for cables

I've just solved a problem that had been bugging me for some time. When faced with the problem of labelling 18 audio and video cables linking the various parts of my video editing suite, I came to the conclusion that the paper labels I had originally used were not durable enough. So I sought something better.

Some time ago I had made a series of transparencies for an overhead projector and I still had left a few sheets of clear acetate film. So I composed the requisite labels on my computer and printed them on the acetate sheet. I then backed the clear labels with plain white adhesive tape, punched the necessary mounting holes and cut out each of the 36 labels, one for each end of the cables. They look quite professional and I expect that they will greatly outlast the previous labels.

The labels are best if slipped onto the wires before the plugs are attached but where this was not feasible, I cut into the side of the holes, slipped the label over the wire and closed the gap with a piece of adhesive tape.

By the way, this method is unsatisfactory if acetate sheet is used with an inkjet printer. The ink takes a long time (30mins) to dry on the acetate sheet and afterwards tends to crack and flake off.

The alternative is to print the labels on paper with the inkjet printer. Then copy them onto acetate sheet in a photocopying machine. After that, the procedure is exactly as described above.

Jim Lawler,
Hobart, Tas.

Double fuses for extra safety

May I revisit the issue of fuses in a circuit? Should it be on the positive supply or negative earth? The air force teaches its technicians to disconnect a battery's earth before the power lead. Consider for a moment, that while disconnecting a power lead with earth still attached, your spanner touches the earthed chassis or frame. The little blue spark can have rather nasty consequences in certain circumstances.

Power inverters or circuits dealing in larger currents are normally fused in the positive supply in contrast to the above principle. In my experience, failure of this sort of equipment often leaves the fuse intact, with power supply capacitors fuelling the fire, so to speak.

My point is that a fuse rated to protect a power circuit provides no protection whatsoever for control circuitry that needs protection of a different order altogether.

This leads me to believe that a good practice is to provide a fuse on the earth side of a logic or control circuit of a power supply to allow the circuit's potential to float; ie, to reduce the potential difference between power and control circuits.

Two fuses allows protection of circuitry used to control power supplies, inverters, voltage cut-outs and so on.

The large fuse would relate to the maximum current in the power circuit, which offers no protection for the control circuit, while the small fuse would be rated at 1.5 times the design current for the control circuitry.

A blown small fuse would allow the control circuit to protect itself by letting its potential float; ie, to minimise the potential difference between power and control circuits.

The resistance of the small fuse would result in negligible shift in voltage values.

Stephen Butcher,
Masterton, NZ. **SC**

International satellite TV part 2. . .

by Garry Cratt*

Last month we discussed the basic principles of satellite TV reception, equipment required and the type of free-to-air programming that is available. This month we explain, in detail, how to install your own C-band (free-to-air) system.

The most important aspect of installation is dish placement. Obviously the dish must be able to point in the right direction to receive a satellite signal. With satellite dishes, "near enough" is most definitely not "good enough." An error or 1°– or even less – can make all the difference on Earth (or off it!).

The "view" to the satellite must be clear of all obstructions. Generally this means locating the dish away from trees, fences and buildings that might obstruct the line of sight to the satellite. As we mentioned last month, a dry tree usually makes only a marginal difference to satellite reception. The smallest rain shower, though . . .

In order to find the best location, a decision has to be made as to which satellite(s) are to be received. The pointing co-ordinates for the desired satellite can be determined mathematically. These days, computer software makes this task relatively simple. We'll look at software shortly.

Azimuth and elevation

The dish pointing co-ordinates will comprise two parts: an azimuth bearing, or the direction the dish must face to point at the appropriate satellite (for Australia that's somewhere between 270° and 90°) and a value of dish elevation, or the angle between the vertical and the axis of the parabolic dish. At the equator, the dish points straight up but the angle increases as you get further south.

Typical values for the most popular satellites and capital cities are shown in Table 1. That's all the information you need to point your dish for a single satellite.

Many people, though, want to look at a range of satellites. As all geo-stationary satellites are located above the equator and as the earth is round, the satellites aren't in a straight line across the sky; rather they follow what is known as a geostationary arc.

To view more than one, a motor is attached to the dish, designed to follow the curve of the arc. It is important to locate the dish so that all wanted satellites are visible to the dish at its extremeties of travel.

A motorised installation is a bit beyond the scope of this article – that's when you really do need professional help.

STEP-BY-STEP: Putting in your own C-band system

Along with the four dish panels (petals), you should get four feedhorn struts (inside the long box) and an LNB cover.

Open up the box of accessories which is supplied along with your dish box. You should find a set of instructions (which will vary from gibberish to excellent, depending on the brand of your dish – and even then not always constant), a plastic bag of nuts and bolts and a mounting plates.

So we will concentrate on viewing the signals from just one satellite.

Councils and neighbours

Most local councils now require a development application to be submitted for the installation of any satellite dish over 1m in diameter (some councils even smaller) and it is wise to check your local council's policy. It's also good policy to install the dish where it will have the smallest impact on the neighbours.

While it might be possible to install the dish in a location not visible to the neighbours (or council), it should be remembered that councils can issue demolition orders for illegally erected satellite dishes (especially big ones!).

One other point about neighbours: it's amazing how paranoid some can get about those nasty microwaves jumping off your dish and curdling the milk in their fridge, causing untold cancers and even rotting the wooden legs on their tables and chairs.

Of course, none of your assurances that it is for receiving only, that it doesn't emit any microwaves, will satisfy them.

One bloke we know finally placated a whining, threatening neighbour by telling him he was actually doing the whole neighbourhood a favour, collecting all the stray microwaves from space in his dish and piping them away. The overall result was less harmful microwaves in the neighbourhood, not more. Yes, it is stupid. But most people are when it comes to things they don't understand. (And yes, the neighbour swallowed it hook, line and sinker).

Site survey

Assuming a position can be found that is both unobtrusive and has a clear view of the sky, the next step should be a site survey. Professional satellite companies always perform a site survey to ensure that there is good access to the satellite signals and just as importantly, that there is no terrestrial interference to the desired satellite signals.

Unfortunately, C band (3.4-4.2GHz) is shared with terrestrial microwave services. Such services can be the source of interference and in some cases, completely prevent the reception of satellite signals.

The site survey is done using a small (1.2m) dish with LNBF and a spectrum analyser. By pointing this small dish using the correct azimuth and elevation values for the desired satellite, the satellite signal can be verified and any interference can easily be seen.

The table at right

Pointing data for major Australian and S-E Pacific capitals. The figure immediately after the city is its magnetic deviation, while the figures underneath are its exact location (usually the major airport). These are given for those who wish to use dish pointing software. To use this chart, select capital city, then satellite number from list below. First data line is magnetic azimuth, second line is elevation. The main satellites listed are prime signal sources. The other satellites (listed underneath) have marginal footprints and may also be received on an itinerant basis. N/A means that the particular satellite is below the horizon for that city and is therefore unviewable.

Even though this size dish is too small to connect to a digital satellite receiver for decoding, it allows the satellite signals – and any interference – to be viewed on the spectrum analyser. Where a dish is not available, even using a standard LNB to detect interference is better than no check at all.

Where interference is detected, it can sometimes be eliminated by using the building itself as a shield. Where a satellite dish is to be installed in a location where there is known interference (eg, near airport radar), the value of using quad shielded coaxial cable can be appreciated. This simple step (choosing quad shielded over the cheaper dual shield) can mean the difference between perfect reception and no reception.

In extreme cases, the coaxial cable can be run inside steel water pipe for even greater immunity to an interfering RF field.

Now we are not expecting you to own a spectrum analyser but you may be able to find a local satellite TV company who will do this for you, albeit at a price.

Digging the hole

The most common installation and perhaps the most manageable is the backyard pole mount.

There is one logical rule that applies here: whatever length of pipe that is above the ground should also be below the ground.

This means that if you plan to install a 2.4m (diameter) dish, you'll need to leave a length of pipe at least half the diameter of the dish (1.2m) protruding out of the ground and another 1.2m buried in the ground. So it's pretty easy to remember – mounting pipe length equals dish diameter.

Dig your post-mounting hole deep enough to accommodate half the post length. For a 2.4m dish, that means 1.2m concreted into the ground. Standard mounting pipe is galvanised 76mm (OD). When you concrete in the post, it is vital that it be exactly vertical AND it stays that way until the concrete has well and truly cured. We normally use standard concrete, not quick-set, because it gives a stronger job.

Butt up two dish panels and finger-tighten just the outermost and innermost bolts with a flat washer under every bolt-head and nut.

Table 1: Dish Pointing Guide for Capital Cities

Satellite No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Orbital Location (°E)		**68.5**	**76.5**	**78.5**	**83.0**	**100.5**	**105.5**	**113.0**	**128.0**	**148.0**	**156.0**	**160.0**	**164.0**	**166.0**	**169.0**	**180.0**
Darwin *(3.5E)* (12°S, 130.5°E)	Azimuth	273	275.3	276	277.5	286.7	291.0	300.3	344.0	051.9	62.1	65.6	068.4	69.6	71.3	76.0
	Elevation	18.8	27.1	29.2	33.9	52.2	57.4	64.8	75.1	65.2	57.4	53.2	49.1	47.0	43.8	32.2
Brisbane *(10E)* (27.5°S, 153°E)	Azimuth	N/A	N/A	266.1	268.3	278.3	281.7	287.6	303.5	338.1	355.3	003.7	011.6	015.4	020.6	036.6
	Elevation	N/A	N/A	5.2	9.2	24.8	29.2	35.8	47.7	57.4	57.7	57.0	55.6	54.8	53.3	46.2
Sydney *(12.6E)* (34°S, 151°E)	Azimuth	N/A	266.0	267.3	270.0	282.0	286.0	292.8	309.9	341.7	356.0	003.0	009.6	012.8	017.4	032
	Elevation	N/A	4.1	5.8	9.5	23.8	27.7	33.5	43.4	50.4	50.2	49.4	48.2	47.5	46.2	40.0
Canberra *(11.9E)* (35°S, 149°E)	Azimuth	N/A	267.8	269.1	271.9	284.6	288.8	296.0	313.8	345.6	359.4	006.0	012.3	015.3	019.2	033.6
	Elevation	N/A	5.6	7.2	10.8	24.7	28.6	34.0	43.3	49.0	48.4	47.4	46.0	45.2	43.9	37.6
Adelaide *(8.0E)* (35°S, 138.5°E)	Azimuth	273.6	278.8	280.1	283.3	298.0	303.2	312.0	333.8	008.0	020.6	026.3	031.6	034.1	037.6	048.9
	Elevation	7.7	14.2	15.8	19.4	32.9	36.4	41.1	47.9	16.1	45.4	43.5	41.3	40.1	38.2	30.5
Melbourne *(11.5E)* (38°S, 145°E)	Azimuth	N/A	272.0	273.3	276.5	290.3	295.0	302.8	321.9	353.3	006.1	012.1	017.8	020.5	024.5	037.3
	Elevation	N/A	8.4	9.9	13.4	26.6	30.1	35.0	42.8	46.1	44.7	43.5	41.9	41.0	39.5	33.1
Perth *(2.5W)* (32°S, 116°E)	Azimuth	298.0	304.9	306.8	311.4	334.6	343.0	354.7	024.2	051.9	059.9	063.4	066.7	068.2	070.4	077.6
	Elevation	27.4	33.8	35.3	38.7	49.2	51.1	52.7	50.5	39.2	33.1	29.9	26.7	25.0	22.5	13.3
Hobart *(14.7E)* (43°S, 147°E)	Azimuth	N/A	268.6	270.1	273.4	287.9	292.6	300.2	318.1	346.3	358.0	003.6	009.1	011.7	015.6	028.6
	Elevation	N/A	5.4	6.8	10.0	22.0	25.2	29.7	36.8	40.5	39.7	38.8	37.7	37.0	35.8	30.6
Auckland *(19.4E)* (37°S, 175°E)	Azimuth	N/A	N/A	N/A	N/A	260.2	263.4	268.5	280.1	300.6	311.1	316.9	323.1	326.2	331.1	349.3
	Elevation	N/A	N/A	N/A	N/A	4.0	7.9	13.8	25.4	38.8	42.8	44.4	45.7	46.2	46.7	46.8
Pt Moresby *(6.6E)* (9.5°S, 147°E)	Azimuth	265.4	266.8	267.2	268.1	272.4	274.0	277.2	289.0	358.8	036.9	047.7	055.0	057.7	061.2	069.2
	Elevation	2.8	10.6	12.7	17.2	35.6	40.9	49.0	65.1	78.8	74.7	71.3	67.4	65.3	62.2	50.4
Honiara *(9.2E)* (9°S, 156°E)	Azimuth	N/A	N/A	N/A	263.1	266.4	267.6	269.6	275.6	298.3	327.0	349.7	012.8	022.4	034.0	056.2
	Elevation	N/A	N/A	N/A	4.1	21.8	27.0	34.9	51.1	71.9	77.8	78.8	77.9	76.9	74.8	64.4
Suva *(12.7E)* (18°S, 178°E)	Azimuth	N/A	N/A	N/A	N/A	261.4	263.1	265.7	272.0	285.5	294.6	300.7	308.0	312.3	319.5	352.7
	Elevation	N/A	N/A	N/A	N/A	3.0	7.7	14.9	29.7	49.4	56.7	60.0	63.1	64.4	66.1	68.6

Satellite Number Index – with type and launch date

1. Panamsat 10, HS 601HP 2001
2. Apstar 2R, FS 1300 1997
3. Thaicom 3, Spacebus 3000A 1997
4. Insat 2e, ISRO 1999
5. Asiasat 2, GE 7000 1995
6. Asiasat 3, HS 601HP 1999
7. Palapa C2, HS 601 1996
8. JCSat 3, HP 601 1995
9. Measat 2, HS 376HP 1996
10. Optus B3, HS 601 1994
11. Optus B1 HS 601 1992
12. Optus A3, HS 376 1987
13. Panamsat 8, FS 1300 1998
14. Panamsat 2, HS 601 1994
15. Intelsat 701, FS 1300 1993

Other itinerant satellite source (craft, launch date & position)

LM-1, A2100AX 1999, 75 E
Gorizont 28, NPO 1993 96.5E
Apstar 1A, HS 376 1994 138E
Apstar 1, HS 376 1996 138E
Agila 2, FS 1300 1997 146
Gorizont 33, NPO 2000 145E
ntelsat 802, GE 7000 1997 174E
Intelsat 702, FS 1300 1994 176E

This magnetic mount Anglemeter has 0.1° accuracy and a large dial face, allowing dish elevation to be read directly.

In practice its best to add 100mm or so out of the ground, so that even if the dish is tilted down for maintenance (rarely required), the lower rim of the dish cannot quite touch the ground, avoiding any possibility of damage.

For mounting most 2.4m dishes, 76mm OD (outside diameter) pipe, available from larger hardware and plumbing stores, is used. For a few dollars more the store will even cut the pipe. In fact, it's quite likely that you will be buying an offcut length anyway, as pipe tends to come in 6m lengths.

Dig a hole at least 300 x 300mm, 1.2m deep and stand the pipe vertically in the centre. To keep the pipe vertical, wedge bricks, rocks, etc between the pipe and the wall of the hole, and check that the pipe is perfectly vertical by using a spirit level.

Check the alignment at two positions 90° apart around the circumference of the pipe. In some circumstances it will be necessary to brace the pipe with two "starposts" or similar.

A 300 x 300 x 1200mm hole is a little over 0.1m^3. You can either use ready-mixed concrete or mix it yourself. For the latter, you will need four bags of standard concrete mix. (If you wanted a really strong mount, a 440 x 450 x 1200mm hole will take about 0.25m^3 of concrete; 10 bags).

Pour the concrete into the hole until it reaches a level 50mm below the ground level. This allows enough room for topsoil to allow grass to grow under the dish. Leave the concrete to set for two days, ensuring that the pipe remains untouched for that period (that includes making sure the kids don't come out and give the pole a jiggle to see if it has set!).

You might be tempted to use rapid set concrete but for maximum strength, ordinary concrete mix is used and allowed to dry normally.

If you are digging the hole in an area comprised mainly of backfill (ie, low density soil) it may be necessary to weld a piece of flat bar across one side of the bottom end of the pipe, to ensure the pipe remains bonded to the concrete. A larger hole would also be more prudent.

Dish assembly

Once the pipe has been set in the ground, the dish can be assembled. Most mesh dishes are supplied as four pre-assembled panels which must be bolted together to form the parabolic reflector surface. Also supplied are four steel or aluminium tubes called "feed struts". These hold the feed horn assembly at the focal point of the dish.

In addition, there is a dish mount. This is the mechanical assembly that connects the reflector to the pipe. It is very cleverly designed so that elevation, azimuth and declination can all be separately adjusted. This is necessary for a motorised dish system, where a single motor makes the dish track in an arc, not a straight line!!

All dishes come with *some* instructions. Depending on the brand, they may be very comprehensive or almost non-existent.

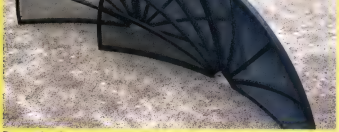
Here are some "generic" instructions based on our experience. Much of the assembly can be performed by one person but several steps require at least two, if not three people.

The main thing to remember is that the performance of the dish is dependent on the accuracy of the surface. So dents and rips in the mesh, apart from not looking at all aesthetically pleasing, will cause a reduction in dish performance and should be avoided at all costs. Even small dents can cause significant degradation and sometimes mean the difference between a good picture and a noisy (or no) picture.

Take two of the dish panels (also known as quadrants) and stand them on their edge. Provided there is no wind (!), and the surface is flat (a concrete driveway is often useful) the panels will stand on their edge, the curve of the panel preventing it from falling over.

Butt up the two panels and insert just the outermost and innermost bolts. Use a flat washer under every bolt-head and nut to prevent crushing the aluminium ribs of the dish panels. Do the nuts up "finger tight". Place this "half dish" assembly to one side and make another half dish from the two remaining mesh quadrants.

Once both halves of the reflector have been assembled, lie them face down on a horizontal surface (perfectly flat if available) with an inverted plastic garbage bin (or something similar) supporting the centre of the dish while you assemble it.



Repeat for the second pair of panels. They will happily stand up like this if there is no wind. But don't risk it in ANY breeze!

Sit both halves on a milk crate or small garbage bin and bolt them together. Now insert the missing bolts and tighten them all up.

Then butt the two halves together and insert the outermost and innermost nuts and bolts. Do these up finger tight. You should now have a reflector lying face down on the ground.

Insert all bolts and nuts (don't forget the flat washers), working from the perimeter of the dish to the centre in a clockwise direction, tightening them with two spanners as you go. There are four mounting holes for the dish mount, so leave them vacant. Don't forget to tighten the nuts you originally had only finger-tight.

Find an assistant, then carefully pick up the reflector and turn it over so it is lying face up. Be very careful if there is any wind: even a mesh dish can get away from you.

The feed struts

The next step is to bolt the feed struts onto the feedhorn. Do this a short distance away from the reflector to eliminate the possibility of accidentally piercing the reflector mesh.

The feed struts should be spaced 90° apart and are secured to the feed ring using four bolts and nuts.

Using that same friendly assistant (or two of them if available), pick up the feed assembly complete with struts, and ***carefully*** position it over the reflector, making sure that none of the struts damage the mesh.

Two people can hold up the feed assembly (each holds the assembly by two struts), while the third person inserts a bolt, washers and nut, at the location point on the reflector.

You should now have a reflector lying face up, with four feed struts bolted to the rim, holding the feed ring at the focal point of the dish. As soon as the feed assembly is secured, there is a noticeable improvement in the rigidity of the entire assembly, as it is secured in both axes.

The dish mount

The next step is to place the dish mount on the pipe protruding from the ground.

As long as the pipe does not protrude more than about 1.5m, one person can generally lift the mount onto the pipe. But it's always better with two. That mount is heavy!

First a few precautions: Ensure that the securing bolts on the outside of the mount sleeve (designed to clamp onto the pipe) are loosened off so that the mount can slide onto the pipe. Fix an azimuth bar (supplied with the dish) to lock the east /west movement of the mount. This prevents the mount rolling around the horizontal axis as you lift it onto the pipe.

Once the mount has been lifted onto the pipe, rotate it such that it is in a position where the dish can be lifted (by two people) onto the mount, then tighten up the mount securing screws to hold it solid.

This is not the final position of the dish, merely a convenient position to finish the assembly. Adjust the mount elevation to about 30°. This will enable you to lift the reflector up against the mount, rather than lifting it above the mount.

Up she goes!

We now need to lift the reflector (dish) onto the mount, orienting it so that the four lugs on the mounting ring correspond with the four double ribs formed by bolting the quadrants together. We also need to consider the LNB securing bolt on the feed horn. This needs to be facing downwards (towards the ground), so it is easier to adjust once the dish is mounted.

With the mount clamped to the pipe, the azimuth bar in place, and using two or three people, carefully lift the upturned reflector and feed assembly onto the mount, positioning the four lugs on the mount and corresponding double ribs.

While one person holds the reflector in place against the mount, another person must insert the four securing bolts. It's necessary to operate from behind the dish to do this, inserting the uppermost bolts first. Don't forget the flat washers under the bolt heads and nuts.

Once the two uppermost bolts have been inserted, the reflector will sit on the mount without support, while the remaining two bolts are inserted.

Now tighten all bolts, making sure the mesh is not damaged by the action of the spanner against the securing nuts. The dish is now ready to have the LNB added and to be pointed towards the satellite.

Pointing the dish

There are four critical parameters that must be determined for every dish installation. They are dish azimuth, dish elevation, LNB orientation and dish focal point.

Fortunately, the focal point is almost always determined by the length of the feedarms. When the feedhorn/LNB is set in correct position, no further adjustment should be needed.

The azimuth and elevation of the dish need to be mathematically calculated. All satellites are given an orbital location, which in the case of Asiasat 2 is 100.5° east longitude. This means that the satellite is located 37,000km

Hopefully your completed dish looks something like this! Be even more careful now you've got this far; from now on it's a 2-man job!

Connect the feed struts to the LNB hardware – do this away from the dish so you don't risk damaging the dish mesh.

This satellite signal indicator comprises a broadband amplifier and diode detector, intended to be used at the dish to assist in signal peaking.

up, at the intersection of the equator and 100.5° east line of longitude.

From a map you'll see that this location is over Indonesia. For Sydney, even the most rudimentary geography indicates that the dish will be facing somewhere in the western sky. Ummmm – west – that's away from the coastline in Sydney.

Fortunately, there are plenty of computer programs available that simply require the latitude and longitude of the dish, together with the longitude of the satellite.You can find a variety of software on the net, some of it freebies.

One such program, GEOSAT.EXE, is one we use at Avcomm Pty Ltd – in fact, we wrote it!

Alternatively, a quick "Google" will find any amount of similar programs, such as SMW Link, from Swedish Microwave AB (www.smw .se/smwlink/smwlink.htm). Make sure you get the latest version (3.05) because earlier versions had a southern hemisphere calculation bug!

But it's often even easier than that, because most modern receivers have a dish pointing menu, where these parameters can be entered to calculate the desired azimuth and elevation of the dish.

Where am I?

You probably don't know the *exact* latitude and longitude of the dish site. To work out the exact (to the minute) location, we normally use either a good map or GPS.

Detailed topographic maps of your area will enable you to extrapolate your exact location because the grid always has at least one (and usually more) latitude and longitude reference on the side.

Alternatively, if you have 'net access you can Google something like "latitude longitude Gulargambone" – especially handy if you happen to live in Gulargambone.

You should find several websites which will give you the exact (to the minute and sometimes even second) location of your town/city, especially if it has an airport. Beware, though, in big cities, the figures are likely to be that of the main airport – and if you happen to live on the opposite side of the city, you could be out by as much as a degree or so.

One further alternative is a very useful book called "The Dick Smith GPS Guide". Available from DSE stores or Australian Geographic, this lists over 16,000 locations in Australia and the corresponding latitude and longitude.

If using this book, its important to remember that most dish pointing programs require latitude and longitude in degrees and tenths of degrees (eg, 34.5) not in the format provide by the book: degrees, minutes, seconds (or 34°30'0"). Fortunately the book does have a conversion chart – and even mental calculations aren't rocket science. (Rocket science? Satellites? Get it . . . ? Oh, don't bother . . .)

Azimuth

One further parameter is required to calculate the dish azimuth – remember, that's the direction it points.

But there is a little wrinkle here called magnetic variation. That's the difference between what you read on a compass as north, and true north (ie, lines of longitude from pole to pole). Magnetic variation varies all over the place depending on the specific place you are at, while computer software invariably works on true north – and you have to add or subtract the local magnetic variation to achieve the desired result.

Magnetic variation can usually be found for any particular location on a specific map called a "WAC" (World Aeronautical Chart), often used by pilots. These charts are available at all good map shops and pilot supply centres. Magnetic variation is also listed on topo maps.

A point to note: as well as varying by location, magnetic variation changes over time. The map may give a misleading figure if it is more than a few years old. Once again, Google is a great way to find out magnetic variation (which is, by the way, also known as magnetic declination). Google '"magnetic variation" Sydney' and you'll find several sites giving the result: 12.6° E.

Very carefully bolt the struts onto the dish using the mounting holes provided. Place the dish assembly somewhere safe.

Here's what the dish mounting hardware looks like straight out of the box (albeit photographed here almost upside down). The cylindrical section with the four bolts at right actually points vertically down (it's the bit which slips over the top of the in-ground 76mm pipe "post"). Those bolts are tightened against the post to ensure the dish cannot "windmill" in strong winds. The ring (on the ground in this pic) is the part which bolts on to the assembled dish.

Recalling the rhyme "east is least" reminds us to subtract lines of magnetic variation marked "E" from the calculated true azimuth. In the case of Sydney the magnetic variation is 12.6° E, so we need to **subtract** 12.6° from the calculated "true" azimuth. The magnetic variation for Perth is around 2.5° W, so we must **add** 2.5 to that "true" azimuth.

Elevation

The dish pointing software calculates elevation directly in degrees. Fortunately, this is much easier to measure and set. The simplest method is to use a protractor and a piece of cotton and a weight but if this is too much trouble a simple analog inclinometer can be purchased reasonably cheaply. This type of instrument has an oil filled chamber with a pivot and a counterweighted pointer.

A far more sophisticated digital instrument is used by professional installers, as the dish geometry of a motorised system must be set to within one tenth of one degree, or six minutes.

The reality is that most home installers will be able to set up a system to look at any single satellite but without sophisticated measuring equipment, the alignment of a motorised system will require professional help.

Where's the satellite?

Now that we have been able to work out the dish azimuth and elevation, we can get to work.

Let's use the example of Sydney and the Asiasat 2 satellite. We know the latitude of Sydney is 34° south, and the longitude is 151° east. We also know that the longitude of Asiasat 2 is 100.5° east.

Our software tells us that the dish elevation must be 23.87°, and the true azimuth is 294.75°. Subtracting 12.6° from the true azimuth gives 282° magnetic. This is the required compass heading.

A cheap and nasty compass won't cut the mustard here: it needs to be a decent, fluid-filled model graduated in individual degrees. Good orienteering compasses are usually a reasonable compromise between cost and usefulness.

Also remember when aiming a dish that the compass itself is likely to be affected by close metal (usually steel) objects. Just keep that in mind if your compass readings keep changing as you move about.

The elevation is somewhat easier to set. Assuming the mounting pipe has no elevation (just like a dish standing on the rim), calibrate the inclinometer for zero degrees. Place

When you get really serious (!) this digital inclinometer has one degree accuracy and resolution. It's a must for setting up motorised dishes.

the inclinometer on the centre plate of the dish (from behind), so that the counterweight is vertical. The elevation of the dish can be directly read.

Adjust the threaded rod until the elevation reaches 24°. This should be close enough, once the dish is pointed in the right direction, to acquire a signal.

One tip – before setting elevation, run the spirit level over your pipe one last time to make sure it hasn't moved before the concrete had a chance to harden. It happens!

Installing the LNB

Now is the time to install the LNB into the feed rings. Do this by slipping the LNB through the ring assembly, so that the front edge of the waveguide protrudes 20mm past the level of the concentric rings. Rotate the LNB so that the flat part of the housing is vertical. This is a good starting point for further adjustments once the system is operational.

This brings us to the next point: how do we measure the signal?

Fortunately, there exists simple in-line signal strength meters for this task. One popular (and economic) type is called, logically enough, a "Satellite Finder".

The meter has an input port that requires DC voltage from the satellite receiver and an output port that feeds that DC voltage to the LNB and reads the amount of signal being sent from the LNB to the receiver.

Basically, it is a simple broadband amplifier and a rectifier driving an analog meter movement and a tone generator. As the signal gets stronger (as we peak up the dish), the meter deflection becomes greater and the tone gets louder. The meter also has a sensitivity adjustment.

Now, having set the dish elevation, set the LNB orientation and calculated the magnetic azimuth of the dish, rotate the entire reflector and mount assembly on the pole

Up the right way: the threaded rod in the centre of the pic adjusts the dish elevation, while the rod at right adjusts declination.

The completed mount. The solid bar (arrowed at left) locks the dish azimuth (set by rotating on the pole). This bar can be replaced by a suitable motor to enable the dish to track any number of (viewable) satellites. But for single-bird systems, this bar is bolted in place as shown here.

until it points in the desired direction.

At this point, connect the LNB to the signal meter and the signal meter to the receiver via short lengths of coaxial cable. Because you are not trying to display a picture right now, you don't need any monitor so setup is most easily done close to the dish with the receiver on a suitably long power cord.

Adjust the meter sensitivity to maximum and turn the receiver on. As the dish assembly is rotated on the pole, the signal strength meter will begin to respond. As the meter reaches full scale, back off the sensitivity while continuing to move the dish, until the signal is peaked.

Carefully adjust the clamping screws on the dish mount so that they are all tightened evenly, clamping the mount to the pole without causing any skew in the vertical plane. It may be necessary to optimise this adjustment several times.

Once this has been done, the elevation adjustment should be optimised for maximum signal, by slowly turning the elevation rod. When this is peaked, lock it in place.

At this stage, select the desired channel on the satellite (most receivers come pre-programmed) and carefully rotate the LNB (with the meter still connected) until the signal is peaked. This adjustment will only be in the order of 10-15°.

Making adjustments greater than this will mean the LNB is peaking on signals of the opposite polarity, as most satellites have signals of both horizontal and vertical polarisation (and sometimes on the same frequency). This adjustment is called cross polarisation optimisation.

Connecting up your system.

Like most pieces of audio visual equipment, a digital satellite receiver has several different outputs for connection to a TV set, VCR or hifi system.

For best results, especially where a recording facility is desired, it is normal practice to connect the direct line audio and composite video outputs from the satellite receiver to the VCR and then use either the RF or (again preferably) the A/V output of the VCR to connect to the TV set.

Most satellite receivers have two or more A/V outputs, allowing separate connections to a hifi system for enhanced audio. However, many overseas stations broadcast in dual mono and often in different languages. In some cases the redundant audio channel is used to carry a separate radio service.

For this reason, satellite receivers allow the user to determine which output will be routed to the sockets on the rear panel.

Assuming there is coaxial cable supplying TV wall outlets in several rooms in the house, the RF output of the satellite receiver can be combined with the existing internal TV cabling to provide a "satellite" channel. While the limitation of this system is that only one channel is fed into the system, it does mean that satellite TV can be enjoyed in many rooms. Anyway, you can only watch one channel at a time, no matter which room you are in!

Channel surfers (or those with the remote control permanently super-glued to their hands) need not apply!

If the ability to record is not required, best results are obtained by running the line audio and composite video outputs of the satellite receiver, directly in to a spare A/V input on the TV set. This is an easy way to switch from normal terrestrial TV to satellite TV.

Most modern TV sets are multi-system, meaning they have the ability to convert an NTSC video signal into a PAL signal. If you don't have one of these, and the station you want to watch broadcasts in the American (NTSC) video format, you may need a video systems converter.

Countries using the NTSC format include USA, Canada, Mexico, Japan, Taiwan and Korea – in fact pretty well anywhere where there has been a US influence in the development of the country, use NTSC.

All other countries use PAL these days (even digital signals from Russia use PAL!). PAL or Phase Alternating Line, is of course the system used for analog TV transmission in Australia.

Analog converters start at $99, while fully fledged digital converters (that allow recording on a PAL VCR) range from $750 to $2000 for a top-of-the-line model (near broadcast quality).

As a digital satellite system is capable of delivering very high quality video, the appropriate quality cables should be used. This means going to a reputable electronics outlet to obtain them.

In the old analog days it might have been possible to put up with the video performance of audio cables, such as the inexpensive twin RCA-RCA types we have all seen.

However, to preserve the quality of the video performance from the satellite receiver, it is important to use well-screened, moulded, three-conductor low capacitance cables, which can normally be identified by the larger

Place the dish on the mount. This is definitely a two-man job (the missing man in this picture was the photographer!) The double edges (joins between the dish panels) slot into the U-shaped brackets on the mount. Place the uppermost bolts and nuts first. Some to-ing and fro-ing of the dish panels might be necessary to get the bolts to go right through the holes in the double-thickness joins. Make sure all dish panel and mounting bolts are tight.

There are four possible adjustments for maximum signal: azimuth, elevation, declination and LNB polarity/focal point. These must be set as explained in the text. In this shot, Erin is setting the elevation – the angle in the sky to which the dish points. Turning the elevation rod raises and lowers the top of the dish with respect to the vertical mounting pole. Azimuth is adjusted even more easily – by rotating the dish on the mounting pole. The focal point is almost always fixed. Don't worry about declination unless setting up a motorised system.

A typical digital satellite receiver – in fact, this or one very similar is the one in the special offer at right.

diameter of the video cable. The effect of using inferior cables will be colour smearing, ringing along the leading edge of the video and generally poor definition.

Do I leave the receiver on?

Most satellite receivers have a standby function, putting the receiver to sleep but allowing voltage up to the LNB. This has the effect of keeping the LNB stable and at a constant temperature. For this reason, it is wise to leave the receiver in the standby mode when it is not being used. This also eliminates the possible ingress of moisture into the receiver itself.

Like all electronic equipment, keep the receiver well ventilated. This is particularly so when several pieces are stacked together in a typical hi fi cabinet. Spacing equipment apart with small blocks of wood can help in this aspect.

Avoid the practise of some people (let's not be sexist here) of putting doilies on top of the receiver (or VCR or CD or DVD or anything else for that matter) and putting a pot plant or vase of flowers on top, "to make it look more attractive". Apart from the fact that this may well cover the ventilation slots and cause overheating, there is always the danger of the vase being knocked over and the internals taking an unwanted and probably highly damaging shower.

For the same reason, empty video sleeves, CD/DVD/cassette cases, etc, should never be placed on top of electronic equipment. **SC**

*** Director, Av-Comm Pty Ltd**

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The LNB is a friction-fit into the feed horn (at the junction of the struts). After fitting and connecting the coaxial cable, you need to adjust the LNB polarity for maximum signal by rotating it in the feed horn. You will probably need to re-adjust elevation and azimuth. To complete the job, run the coax down one of the struts and secure it with black cable ties (white ones will break down over time due to UV). Make a loop around the back of the dish and cable-tie the coax to the mounting post.

And now it's finished. We've left the LNB cover off for clarity (quite often they are left off anyway!). The coax is connected to the LNB and secured to the strut and post – now it is just a matter of connecting it to your satellite receiver, tuning in the required channel and watching your satellite programs. After the dish has settled in, it might pay you to re-peak the azimuth, elevation and LNB output as previously detailed. But if you have wall-to-wall signal, it's probably not worth the bother. Enjoy!

READER/ PROGRAMMER FOR SMART CARDS

Since blank smart cards are now available at attractive prices, it's quite feasible to program them with your own software and data for all kinds of applications. Here's a low cost and easy to build 'Phoenix type' reader/programmer, which can be used with most of the programming software available on the Web to suit this type of serial-port device.

With their embedded microcontroller and serial EEPROM combination, today's 'smart cards' have many more uses than dumb cards which merely have a magnetic stripe.

Smart cards are already used for pay TV set-top box and mobile phone authorisation but these applications really only scratch the surface of their potential.

You could use them to build your own personalised security access system, for example, or to provide a 'plug-in brain and memory' for small robots and digitally controlled machines. Or to provide plug-in schedules for automatic control of a model railway, or pointing data for a computer-positioned telescope, or whatever...

Using smart cards for your own applications is now quite feasible because blank smart cards and matching 'sockets' are now available at quite reasonable cost.

For example, Jaycar stores are offering blank cards with an embedded PIC16F84A micro and 24LC16B EEPROM for $19.95 (Cat ZZ-8800). Jaycar can also supply suitable 'sockets' in both through-hole (PS-0012) and SMD (PS-0010) versions for only $8.75 each.

By the way, the PIC16F84A microcontroller chip (made by Microchip Technology) is used in many of the commonly used smart cards. Although only an 8-bit processor it's quite powerful, with 1024 words of program memory, 68 bytes of data RAM and 64 bytes of data EEPROM.

It is even smarter when it's teamed up with the 24LC16B serial EEPROM (which has a capacity of 16K bytes); the combo is capable of a surprising range of applications.

Other smart cards team up the PIC16F84A micro with a 24C64

By David Freeman

EEPROM which offers 64K bytes of memory. The Atmel AT90S8515 micro is also used in some smart cards. Usually it's teamed up with either the 24C64 or 24C128 (128K bytes) EEPROM.

Fig.1 shows what's actually inside a common smart card, of the type using the PIC18F84 with a 24LC16. Because both chips use serial communication, all of the connections to the 'outside world' are made via only five of the tiny array of eight gold-flashed contacts.

Contact C1 is used to supply the chips with +5V, C2 to reset the micro, C3 to provide the micro with clock signals (3.75MHz or 6.0MHz), the large 'L shaped' C5 for ground and C7 for serial data input amd output.

This kind of card makes a compact (86 x 54 x 0.8mm) and cost effective package containing such a useful micro and EEPROM. How they can fit those chips, bonding wires and contacts inside a card with a total thickness of only 0.8mm is beyond me!

They can, of course, because the cards are available over the counter as well as being used in pay TV set-top boxes and mobile phones. So because the matching sockets are readily available as well, it has become quite feasible to use them in your own projects.

All you really need for this is a small hardware interface to connect the card up to your PC, and suitable software to allow you to 'talk' to the card's micro for reading and programming. (Note that the card's EEPROM is read and programmed 'through' the micro, with its 'cooperation'.)

In this article, I'm describing a simple reading/programming interface which is quite low in cost and easy to build. I can't claim it involves any great design innovation.

In fact, it's very similar to quite a few designs that have been available on the Internet and like them, based on what seems to be called the 'Phoenix' configuration.

(I haven't been able to find out where that name came from – perhaps the person who came up with the first design lived in Phoenix, Arizona!)

The main advantage of using this kind of design is that it's compatible with a lot of the smartcard reading and programming software available for free downloading from many sites on the internet.

By the way, SILICON CHIP will NOT

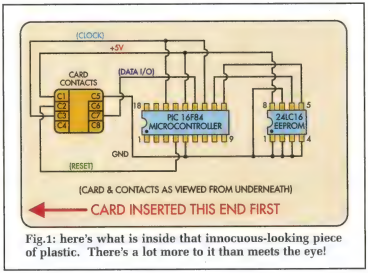
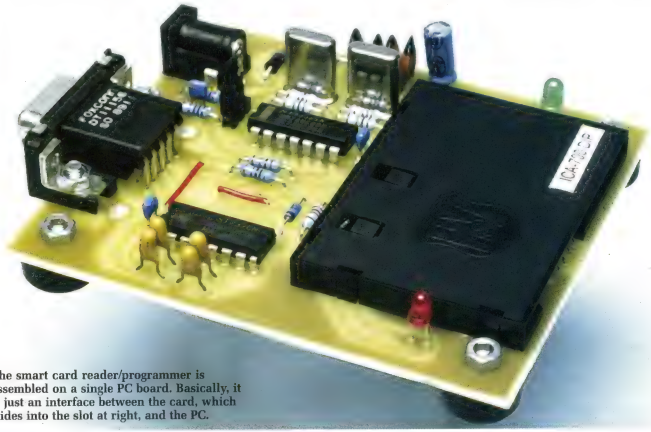


Fig.1: here's what is inside that innocuous-looking piece of plastic. There's a lot more to it than meets the eye!



The smart card reader/programmer is assembled on a single PC board. Basically, it is just an interface between the card, which slides into the slot at right, and the PC.

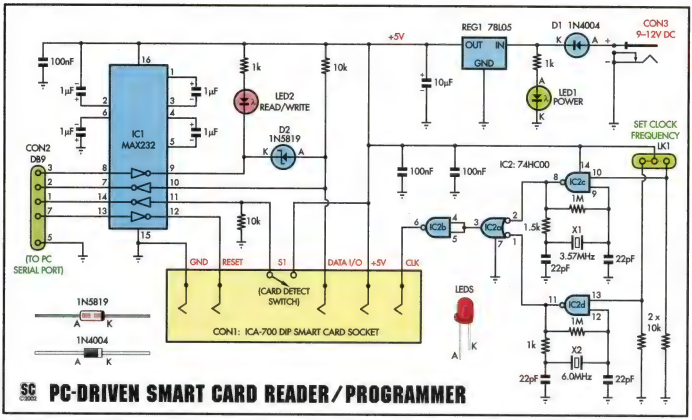


Fig.2: the complete circuit. There's not much to it – just a couple of crystal oscillators, an RS-232 chip and power supply.

be able to provide you with any software to go with the hardware, because according to Australian federal law this combination of hardware and software is capable of being 'used for the purpose of defeating encryption systems', and is accordingly deemed illegal.

Needless to say, we are certainly not describing this project with the idea that you would use it to defeat any encryption systems. In fact we must warn you that it should NOT be used for this purpose, because doing so would be illegal and make you liable to be prosecuted.

All we can do with regard to helping you find suitable software is list the URLs for some of the web sites where you may be able find some, and leave the rest to you.

These are shown in the accompanying panel. Be warned again, though: some of the software on these and other sites MAY be designed specifically for illegal smart card applications.

So let the user beware!

Incidentally, we understand that kits for this hardware interface will be available from Jaycar Electronics. So you shouldn't have any problems building up the interface itself or getting blank smart cards for use with it.

Free-standing board

As you can see from the photo, there's very little in the project and all of its components fit on a small freestanding single-sided PC board. The board measures only 89 x 76mm, and is coded 07201031. It's supported on four small rubber feet and has the smart card socket on the front, flanked by two LEDs: one (green) to indicate when the unit is powered up, the other (red) to show when the PC is reading from or writing to the card.

Here's a selection of "blank" smart cards showing different types of contacts available. This reader/programmer suits only the 8-contact version, as shown on the left.

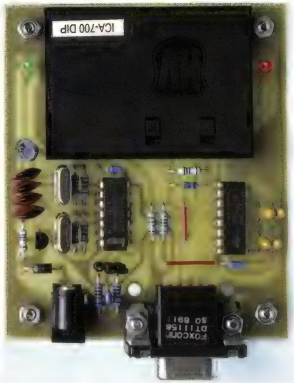
Along the back of the board are a DB9F socket for a standard RS-232C serial link cable to the PC serial port, plus a 2.5mm concentric DC power connector to accept the cable from a 9-12V plugpack power supply. Everything else is on the board itself.

Circuit description

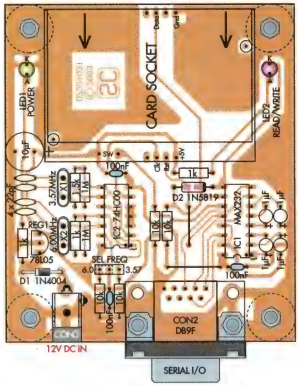
The hardware of this project is designed to perform just three main functions: (a) to provide +5V DC to the smart card plugged into its socket; (b) to provide the card with a clock signal of either 3.75MHz or 6.0MHz, selectable via a jumper shunt; and (c) to provide a serial communications interface between it and the PC's software, to allow reading and writing.

Referring to the circuit diagram, power for the interface is derived from a 9-12V DC plugpack, connected to the unit via CON3. Series diode D1 prevents damage due to an accidental reverse polarity connection, while low power regulator REG1 provides smoothed and regulated 5V DC for both the smart card and the rest of the interface circuitry. LED1 is the green power indicator, which runs directly from the unregulated input.

Clock signals for the smart card are provided by the circuitry around IC2,



Full-size view of the completed PC board. . .



. . . along with the matching component overlay.

a low-cost 74HC00 quad gate. Two of its gates (IC2c/d) are connected as crystal oscillators, one for 3.75MHz using crystal X1 and the other for 6.0MHz using X2. Which oscillator runs at any particular time is determined by the position of the jumper shunt in the 3-pin header LK1, because this applies +5V to the second input of either IC2c or IC2d.

Each oscillator only operates when its second gate input is taken to +5V, so the oscillator whose second input is held low via the 10kΩ resistor is disabled.

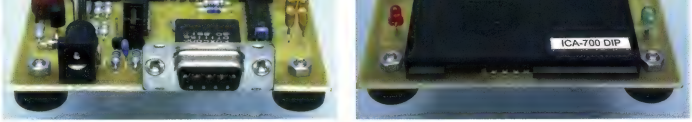
The outputs of the two oscillators are fed into IC2a, used here as an OR gate. Then the clock signals are passed through IC2b, used as a buffer, before being fed to the CLK pin of the smart card socket (C3).

The rest of the circuitry forms the interface between the smart card and the serial port of the PC (via CON2). The heart of the interface is IC1, a standard MAX232 dual RS-232C serial bus transceiver. This chip is very handy because it contains internal 'charge pump' circuitry which generates the correct RS-232C voltage levels from a standard +5V supply rail, using the four 1µF capacitors connected to pins 1-6.

One of the two receivers of IC1 has its input (pin 8) connected to the transmit data line from the PC (TxD, pin 3). The output of this receiver (pin 9) is used to operate LED2, the Read/Write indicator. The same output is also used to pull down the Data I/O pin on the smart card socket (C7) via Schottky diode D2, to send data to the card during write operations.

The smart card pin (Data I/O) is normally pulled high by a 10kΩ resistor to +5V but can easily be pulled low by pin 9 of IC1 because of the very low voltage drop in D2.

When the smart card micro itself pulls the Data I/O pin low during a read operation, this is fed back to the



Fore and aft close-up views of the business ends of the smart card reader/programmer, showing the RS232 and power supply connections (left photo) and the smart card slot (right photo)

Parts List – Smart Card Reader/Programmer

1 PC board, code 07201031, 89 x 76mm
1 3.57MHz crystal (X1)
1 6.00MHz crystal (X2)
1 3-pin SIL header strip with 2-way jumper shunt (J1)
1 ICA-700 DIP smart card socket (CON1)
1 DB9F connector, 90° PCB mount (CON2)
1 2.5mm DC power connector, PCB mount (PS-0520) (CON3)
4 M3 x 6mm cheesehead machine screws
2 M3 x 9mm cheesehead machine screws
6 M3 hex nuts
4 small rubber feet, screw attachment type

Semiconductors

1 78L05 low current regulator(REG1)
1 MAX232 or ST232CM interface (IC1)
1 74HC00 quad NAND gate (IC2)
1 3mm green LED (LED1 — power)
1 3mm red LED (LED2 — read/write)
1 1N4004 power diode (D1)
1 1N5819 Schottky signal diode (D2)

Capacitors

1 10µF 16V RB electrolytic
4 1µF tantalum
3 100nF metallised multilayer ceramic (code 100n or 104)
4 22pF NPO disc ceramic

Resistors (0.25W 1%)

2	1MΩ	(brown black green brown	or	brown black black yellow brown)
4	10kΩ	(brown black orange brown	or	brown black black red brown)
1	1.5kΩ	(brown green red brown	or	brown green black brown brown)
3	1kΩ	(brown black red brown	or	brown black black brown brown)

serial port (CON2) via one of the IC1 transmitters, as pin 10 is also connected to this point. The output from pin 7 of IC1 is connected to pin 2 of CON2 which is the RS-232C receive data (RxD) line.

The second receiver of IC1 has its input (pin 13) connected to the Ready to Send (RTS) line from the PC (CON2 pin 7), and its output (pin 12) to the Reset pin of the smart card socket. This allows the software in the PC to issue a reset command to the micro in the smart card whenever this is required.

The input of the second transmitter section of IC1, pin 11, is connected via a 10kΩ resistor to ground but also to one side of the card socket's built in card sensing switch. The other side of the switch is connected to +5V, so when a card is inserted into the socket and pushed right in, the switch operates and pin 11 of IC1 is pulled high.

The output of this transmitter (pin 14) thus swings to RS-232 'mark' level, and as this output is passed back to the PC via the 'carrier detect' line (CD, pin 1) of the serial comms port, this allows the software to monitor when a card is present in the socket.

Putting it together

You shouldn't have any trouble putting the interface together if you follow the board assembly diagram carefully, as a guide to positioning the various components and their orientation.

I suggest that you fit the card socket, the DB9 connector and the DC power socket to the board first, as all three of these may need a small amount of board hole 'tweaking' before their pins all mate with the board correctly. It's easier to do this before you add all of the other components.

Note that the card socket mounts with its card entry slit towards the front(!), and that as well as the various contact connection pins it also has a couple of 3mm diameter plastic locating spigots which sit in matching holes in the board.

Once the three connectors are fitted and soldered in place, you can then add the remaining components in the usual order. That is, wire links first (there are only two), then the 3-pin SIL header, then resistors, capacitors and crystals. Finally come the diodes, regulator, LEDs and ICs.

As always, make sure you fit all polarised parts with the correct polarity as shown in the diagram.

Both LEDs have their cathode 'flat' side towards the front of the board, while both ICs have their notch end towards the back. Take special care with the polarity of the four 1µF tantalum capacitors on the outer side of IC1.

When the board is fully assembled, the four small rubber feet can be attached to it using M3 x 6mm machine screws and nuts.

The feet are important with this kind of 'naked board' assembly because they give the board proper support while lifting the solder joints away from whatever surface the interface may be placed on.

That's about it. Your smart card

Where to look for software

Here are some website links where software compatible with this smart card reader/programmer is available for free download:

www.adteknik.se/engiish/
www.angelfire.com/space/aussiemulate/
www.maxking.co.uk
www.maxkingtunisia.com
www.skyvisiontech.com/card_reader.htm

Note that neither SILICON CHIP nor the author of this article can accept responsibility for the operation of any of this software or its potential to be used for unlawful purposes.

interface should now be ready to use, but before hooking it up to one of the serial comms ports of your PC you might want to give it a quick check-out.

1-minute checkout

To do this, connect the output cable of the 9V plug pack to CON3, and apply power to the plugpack.

Power indicator LED1 should immediately light — if not, remove the power and check that you've fitted it the right way around.

The only other reason for 'no glow' is that you may have wired in diode D1 in wrong way around, or the plug is fitted to the plug pack output cable with the connections reversed.

Assuming the LED is happily glowing, check the DC voltage at pin 14 of IC2 and pin 16 of IC1 with your DMM. In both cases you should get a reading within a few millivolts of 5.0V, and you should also be able to measure the same voltage at the '+5V' pin of the card socket and/or the end of the 1kΩ resistor right next to it (and alongside D2).

If these voltages measure OK, you must have connected the regulator in the correct way around.

At this stage your interface is probably working as it should. However, if you have access to a scope (CRO) you might also want to check the crystal oscillators.

This too is very straightforward. With the unit powered up, try fitting the jumper shunt joining the centre and lefthand pins of the SIL strip (looking from the front). With the scope probe on pin 6 of IC2, you should find a 5V peak-peak square wave of 3.75MHz.

If you shift the jumper shunt to join the centre and righthand pin instead, the waveform at pin 6 should simply change in frequency to 6.0MHz.

Assuming this is what you find, you can conclude that your smart card reader/programmer is all present and correct.

All you need now is a cable to connect it to a spare comms port of your PC and of course some software so that your PC knows how to talk to a card plugged into the front socket. Plus a card or two, of course...

Incidentally there's a lot of specialised knowledge and jargon associated with some areas of smart card technology.

You'll find a lot of this explained in some of the documentation files available on the Angelfire website.

If you'd also like more information on the PIC 16F84A micro and the 24LC16 EEPROM, this can easily be downloaded from the Microchip website (www.microchip.com).

There are applications notes available as well as device data sheets — most of them in PDF file format.

So once you have the interface, your future with smart card technology will await. Over to you! **SC**

Where from, how much...

This project was designed for Jaycar Electronics and is only available through Jaycar Electronics stores, dealers and mail order service.

Expected retail price is around $29.95. Jaycar also have blank smart cards available for $19.95 each. Contact your nearest Jaycar Electronics store.

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Requires a +15/-15 supply and is ideal for general purpose. Supplied with PCB and components.

K.5611

CLEARANCE WAS $17.88 $12.52

SILICON CHIP Sep '01

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K.7211

CLEARANCE WAS $19.80 NOW $13.86

SILICON CHIP Sep '98

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K.5620

CLEARANCE WAS $29.90 NOW $20.93

SILICON CHIP Aug '01

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K.5421

CLEARANCE WAS $64.70 NOW $45.29

Ea. Aug '96

Pocket Sampler Kit

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K.7345

CLEARANCE WAS $33.80 NOW $23.66

SILICON CHIP May '02

Battery Guardian Kit

Disconnects power to appliances if battery runs low. Automatically reconnects power when the battery is recharged. Supplied with PCB, case and all necessary components.

K.3121

CLEARANCE WAS $39.88 NOW $27.92

Ea. Aug '98

Soundcard Pre Amp Kit

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K.7347

CLEARANCE WAS $43.90 NOW $30.73

Ea. Jun '99

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K.7207

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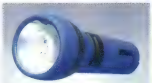
K 3020

CLEARANCE WAS $49.88 NOW $34.92



Silicon Chip May '01

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K 3019

CLEARANCE WAS $59.90 NOW $41.93

Silicon Chip Feb '99

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K 3167

CLEARANCE WAS $18.90 NOW $13.23

Ea. Aug '88

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K 3410

CLEARANCE WAS $22.75 NOW $15.93

Ea. Aug '97

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K 3160

CLEARANCE WAS $29.50 NOW $20.65

Silicon Chip Feb '00

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K 4209

CLEARANCE WAS $73.50 NOW $51.45

AEM Aug '88

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K 3548

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Ea. Mar '00

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FEATURE PROJECT

Build the

– a new, high perfor

By LEO SIMPSON & PETER SMITH

The transmogrification of an amplifier. Many readers will recognise the venerable (26-year-old!) ETI-480 top left. But the SC480 (bottom right) is as modern as tomorrow – with performance to match.

Performance

Output Power	*50 watts into 8Ω; 70 watts into 4Ω*
Music Power	*77 watts into 8Ω; 105 watts into 4Ω*
Frequency response	*-1dB at 14Hz and 70kHz (at 1W – see Fig.1)*
Input sensitivity	*0.875V for 50W into 8Ω*
Harmonic distortion	*<.05% from 20Hz to 20kHz; typically <.003%*
Signal-to-Noise Ratio	*-114dB unweighted (22Hz to 22kHz); -119dB A-weighted, both with respect to 50W into 8Ω*
Damping factor	*>140dB at 100Hz & 1kHz, with respect to 8Ω and without PTC thermistor*
Protection	*fuses plus "Polyswitch" PTC thermistor*
Stability	*unconditional*

ESC 480

ance amplifier module

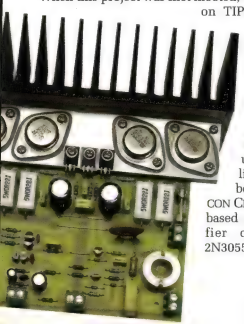
Have you built one – or more – of the popular ETI-480 power amplifier modules over the years? Here is the module to replace that old design. The SC480 produces a great deal less distortion, is much quieter and has inbuilt protection. It also sounds much better.

Back in the October 2002 issue we noted that we intended to produce a replacement module for the very popular ETI-480 amplifier module which was published back in December 1976 – 26 years ago.

In the same note we stated, somewhat controversially, that the ETI-480 was a dog of an amplifier and that it was not a good performer, even by 1976 standards.

Having made that outrageous statement (to some readers, at least), we had to come up with the goods. Fortunately, we were pretty confident that we could, and we are pleased to state that this new module is even better than we had hoped. It uses the same power output transistors as in the ETI-480 and just one more low-cost transistor has been added to the overall component count. Kit cost should be about the same as for the ETI-480.

When this project was first mooted, we decided to base it on TIP3055 and TIP2955 plastic power transistors. These are 60V 15A 90W transistors in the TO-218 (SOT-93) encapsulation.



We intended to produce a new version of a 100W module which was published in the December 1987 issue of SILICON CHIP. That design was based on a Hitachi amplifier circuit and used 2N3055/MJ2955 power transistors in TO-3 metal encapsulation.

Accordingly, we produced a PC board pattern for the new module and while we waited for it to be produced by RCS Radio Pty Ltd (thanks Bob), we realised that a substantial number of readers who had built countless ETI-480 modules would probably like to "graduate" to our new design but would wish to at least re-use the TO-3 power transistors from their ETI-480s on the new board.

Hence, the idea of a TO-3 version of the new module also came to pass, as is featured here.

The plastic version of the module has the power transistors lined up along the back edge, making it easy to mount them to the vertical surface of a finned heatsink.

The TO-3 version is larger and has the four power transistors mounted on the horizontal shelf of a cast heatsink or on a rightangle bracket which can then be mounted on a vertical heatsink.

Why publish both modules? The simple answer is that we had produced them both, so why not? However, each module has its own advantages.

Version 2, using the TO-3 transistors, is rugged but takes up more space and is likely to be less convenient to mount in a typical chassis. There is also more work in assembling Version 2 with the TO-3 transistors.

Version 1, with the plastic power transistors is quite a bit more compact and less trouble to mount in a typical chassis but the module assembled onto a heatsink is not quite as rugged to handle.

By the way, if you decide to build Version 1, don't be tempted to substitute the (usually) cheaper MJ"E"... versions of the transistors. These TO-220 transistors are rated lower (only 75W) and will inevitably cause you great pain and suffering.

Which version to build?

Our preference is for Version 1 but we have a sneaking suspicion that Version 2, with the TO-3 power transistors, will be the more popular module (especially amongst those looking for a somewhat look-alike ETI-480 substitute).

Depending on the particular brand of power and driver transistors used, both modules will give virtually identical performance.

Regardless of which version you decide to build, the performance will be vastly better than the old ETI-480 design.

And that is as it should be. After all, we should have learnt quite a bit about amplifier design in 26 years or so, shouldn't we?

Performance

Power output is 50 watts RMS into a 8Ω load and 70 watts into 4Ω load, before the onset of clipping. Music power is around 77 watts into 8Ω and 105 watts into 4Ω.

Hang on a minute! Wasn't the ETI-480 claimed to be 100W into 4Ω? Well, it was but the distortion graph published by ETI back in December 1976 shows the amplifier heading well into clipping at around 70W RMS. This is to be expected since both the ETI-480 and the new SC480 use the same voltage rails and the same output transistors.

A particular feature of the SC480 is low distortion. Distortion for all power conditions, up to clipping, into an 8-ohm load, is less than .05% for the full range of frequencies from 20Hz to 20kHz.

Similarly, with a 4-ohm load, total harmonic distortion is less than .07% for the full audio frequency range.

In reality, this is a very conservative rating as the distortion will typically be .003% or less for both load conditions. And for very lower power levels, less than 100mW, where noise becomes a significant part of the measurement, the distortion is really low, down to as low as .0005%. This is two orders of magnitude better than the ETI-480!

Signal to noise ratio is better than -114dB (unweighted, 22Hz to 22kHz) with respect to full power into an 8Ω load. Frequency response is just 1dB down at 14Hz and 70kHz (see Fig.1).

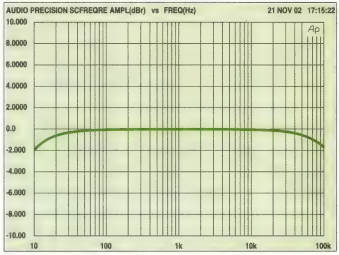


Fig.1: this is the frequency response of both versions of the new amplifier, taken at a power level of 1W into an 8Ω load.

Transistor quality

As in most things, you get what you pay for and it is no different with these modules.

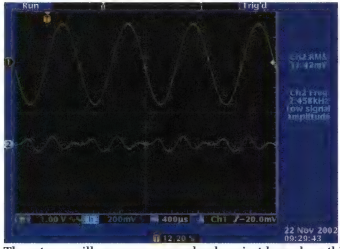
The plastic version (Version 1) of the amplifier was built with the output and driver transistors in what we would call the premium brands: Philips, Motorola (On Semi) and ST Micro.

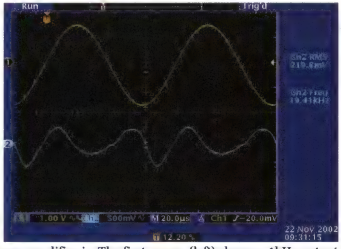
Version 2 was built with second rank power and driver transistors (Mospec). We did this to compare performance and we are pleased to report that although the premium branded transistors do give slightly better performance, there is a not a lot in it.

Refer to the distortion graphs of Figs.2-9 to make the comparisons.

Either way, the performance of these modules is very good, especially considering that we are not using expensive transistors such as Motorola MJL21193/4 or the even more expensive MJL1302A & MJL3281A.

In fact, in some respects the measured performance challenges that of our popular and more powerful Plastic Power module published in the April 1996 issue. Interest-





These two oscilloscope screen grabs show just how clean this new amplifier is. The first screen (left) shows a 1kHz output waveform at a level of 40W into 8Ω at top. The lower trace is the distortion waveform which has been "averaged" by the scope to remove noise. Note that it is mostly second harmonic distortion. The same process has been applied to the screen shot at right except that it is a 10kHz signal. Again, the distortion is mainly second harmonic.

ingly, a key part of that performance standard comes about because of improved PC board and wiring layout.

We'll discuss these vitally important aspects in more detail later in this article.

Oh, and we should state that the SC480 Version 1 and Version 2 modules are a drop-in replacement for the ETI-480 modules but will sound a great deal better.

While nominally of the same rating, they will deliver more power, they're quieter and as already detailed, much lower in distortion.

By the way, these modules are not suitable for driving 2Ω loudspeakers as used in car sound systems. We do not have space to publish the load/line curves in this article but suffice to say that attempting to drive 2Ω loads will blow the fuses and may blow the output transistors as well.

Protection

The trouble with all high-power amplifiers is that, if a transistor fails, there is a big chance that the loudspeaker system could be damaged, despite having fuses in the power supply.

The problem is that the fault condition may place a large DC voltage across the speaker's voice coil and the resulting current may not blow the fuses. The speaker's voice coil then gets red hot and may actually set the speaker cone on fire! Once that happens and if you're not there to kill the power to the amplifier, you can have a raging fire in your home and enormous amounts of smoke being generated by the burning of the filling material in the cabinet.

Our normal approach to this problem is to incorporate relay protection which will disconnect the loudspeaker in the event of a large DC fault condition occurring in the amplifier.

Relay protection works as far as the speaker is concerned but it doesn't protect the amplifier itself if the loudspeaker leads are shorted. Here again the fuses may not blow before the output transistors are damaged.

Neither do fuses protect the speakers if you seriously over-drive the amplifier. This is a particular risk for tweeters but even woofers can have voice coil damage by serious over-drive.

Complete protection

The method we have used to provide protection to both the loudspeaker and amplifier is to connect a high current positive temperature coefficient (PTC) thermistor (known commercially as a "Polyswitch") in series with the output circuit. This is the same method of protection as we used in the original module published in December 1987.

The PTC thermistor normally has a very low resistance but when the current through it rises to high value, it immediately switches to a high resistance state and stays in that condition until the fault is fixed or power is removed.

The resistance of the PTC thermistor is so low (typically 0.1Ω or less), it has a negligible effect on amplifier performance, apart from the fact that it does cause a reduction in damping factor.

In practice, it works extremely well. It allows you to drive the amplifier to full power on program signals but the moment a short circuit is applied or the amplifier is seriously over-driven, the PTC thermistor goes high in resistance to cut off the fault current.

After the protection thermistor has switched to its high state, it takes some time to revert to its low resistance condition, after the fault current has ceased. This depends on how much current is passing through it. If the drive level is maintained after a fault has occurred, the protection thermistor will stay high in resistance.

Circuit description

Now let's have a look at the circuit of Fig.10. 13 transistors and three diodes make up the semiconductor complement.

The input signal is coupled via a 1μF bipolar electrolytic capacitor and 2.2kΩ resistor to the base of Q2. Q2 & Q3 make up a differential pair. Q1 is a constant current source which sets the current through Q2 & Q3 and renders the amplifier largely insensitive to variations in its supply

Just to confuse you, Version 2 of the SC480 amplifier (with TO-3 transistors) is on the left, while Version 1 (with TO-218 transistors) is on the right. There is only a small difference in performance between the two versions.

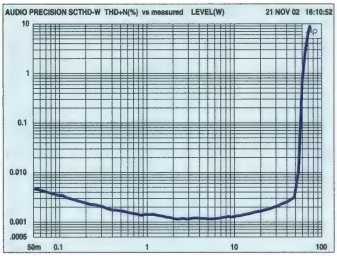


Fig.2: THD versus power at 1kHz into an 8Ω load for Version 1 (TO-218).

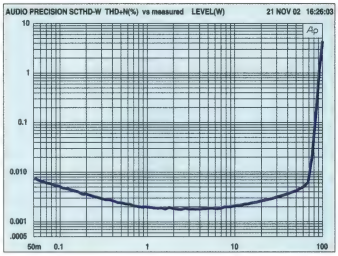


Fig.3: THD versus power at 1kHz into a 4Ω load for Version 1 (TO-218).

rails (power supply rejection).

Signals from the collectors of Q2 & Q3 drive another differential pair, Q4 & Q5 which have a "current mirror" as their collector loads. The current mirror, comprising D3 and Q6, ensure that this second differential stage has high linearity (ie, low distortion).

The output of Q5 is then used to drive class-AB output stage consisting of drivers Q8 & Q9 and power transistors Q10, Q11, Q12 & Q13.

Q7 is a Vbe multiplier, so-called because it multiplies the voltage between its base and emitter to provide a fixed voltage between its collector and emitter, regardless of the drive current delivered to the output stage by Q5. The voltage is adjusted by trimpot VR1.

The function of Q7 is to set the DC voltage applied between the bases of Q8 & Q9. By doing this it sets the "quiescent current" in the output stage (ie, the current when no signal is present). This is to minimise crossover distortion. In fact, our tests did not reveal any signs of crossover distortion.

The complementary output transistors are connected in parallel to give high output current capability. Each transistor has its own 0.22Ω emitter resistor. These are included to ensure that the output current is shared reasonably well between the output transistors.

Negative feedback is applied from the output stage back to the base of Q3 via a 22kΩ resistor. The level of feedback, and therefore the voltage gain, is set by the ratio of the 22kΩ resistor to the 1kΩ at the base of Q2. The 47μF bipolar capacitor in series with the 1kΩ sets the DC gain to unity and sets the -3dB point of the frequency response to about 3Hz. The other determinant of the amplifier's low frequency response is the 1μF input capacitor and the 22kΩ base bias resistor feeding Q1 and these set a -3dB point at about 7Hz.

The 330pF capacitor together with the 2.2kΩ resistor feeding Q2 form a low pass filter to roll off frequencies above 200kHz.

The 68pF capacitor between the base and collector of Q5 and the 10pF capacitor between base and collector of Q2 roll off the open-loop gain of the amplifier to ensure stability with feedback applied. Note that the 68pF capacitor can be a ceramic or polystyrene type and must a have a voltage rating of 100V or more. Other capacitor types are not recommended.

Another important factor in the amplifier's excellent

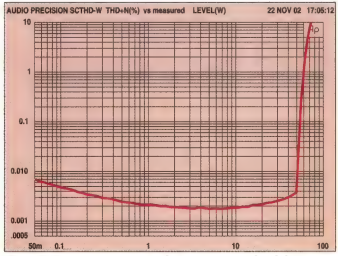


Fig.4: THD versus power at 1kHz into an 8Ω load for Version 2 (TO-3).

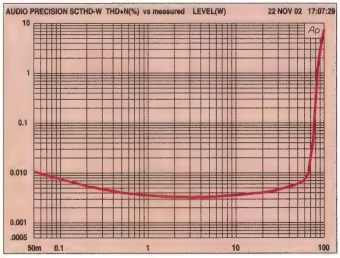


Fig.5: THD versus power at 1kHz into a 4Ω load for Version 2 (TO-3).

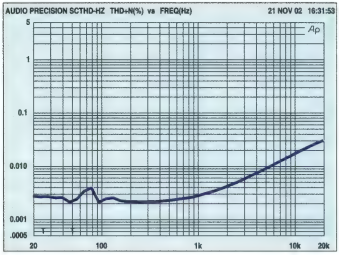


Fig.6: THD versus frequency at 40W into an 8Ω load (Version 1).

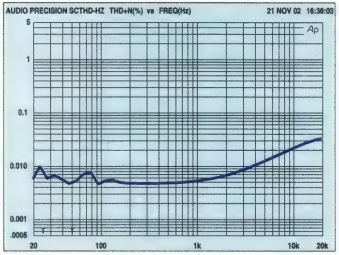


Fig.7: THD versus frequency at 60W into an 4Ω load (Version 1).

stability is the output RLC network consisting of the 6.8µH choke, a 6.8Ω resistor and a 150nF capacitor. Not only does this network ensure stability but the capacitor is an effective killer of any RF and mains-interference signals which can be picked up by long loudspeaker leads.

Power supply

The power supply circuit is shown in Fig.11. This uses a centre-tapped 56V transformer driving a bridge rectifier comprising four 1N5404 diodes and two 4700µF 50V filter capacitors. This produces unregulated supply rails of about ±40V.

Depending on the mains AC voltage, the rails will drop to around ±32V or less when the amplifier module is delivering full power into a 4Ω load.

We have also provided a ±15V DC supply for a preamplifier. This is derived with 2.2kΩ resistors and two 15V 1W zener diodes.

PC board topology

As noted earlier, the design of the PC board is a very critical part of the overall circuit. The placement of the components and the way that heavy currents flow in the tracks is all arranged to minimise the radiation of harmonics into the input stage involving Q1 & Q2.

This board is yet a further refinement of the topology we first introduced in the Ultra-LD amplifier featured in March, May & August 2000 and then again in November & December 2001. The PC board for version 2 and the component placement is shown in Fig.12.

It incorporates "star earthing" whereby all earth currents come back to a central point on the board, thereby avoiding any flow of output, supply and bypass currents flowing in the signal earths.

Furthermore, placement of the copper tracks to the output stages is arranged, as far as possible, to cancel the magnetic fields produced by the asymmetric currents drawn by each half of the output stage.

By way of explanation, when the positive half of the output stage (Q10 & Q12) conducts, the DC current drawn is effectively a positive half wave (ie, rectification takes place) of the signal waveform. And when the negative half conducts (Q11 & Q13), the DC current is the negative half wave.

A major cause of harmonic distortion in class-B amplifiers is the magnetic fields produced by these asymmetric

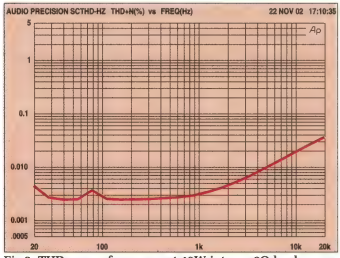


Fig.8: THD versus frequency at 40W into an 8Ω load (Version 2).

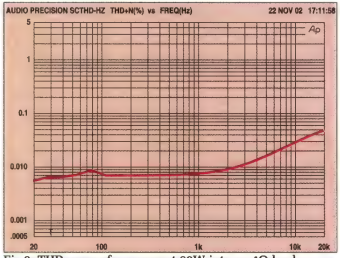


Fig.9: THD versus frequency at 60W into an 4Ω load (Version 2)

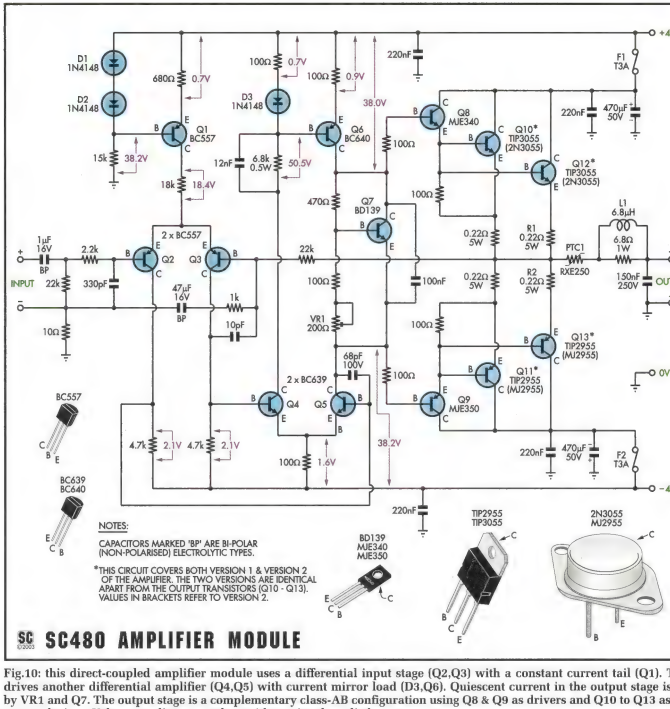


Fig.10: this direct-coupled amplifier module uses a differential input stage (Q2,Q3) with a constant current tail (Q1). This drives another differential amplifier (Q4,Q5) with current mirror load (D3,Q6). Quiescent current in the output stage is set by VR1 and Q7. The output stage is a complementary class-AB configuration using Q8 & Q9 as drivers and Q10 to Q13 as the output devices. Voltage readings are taken with no signal applied.

currents inducing unwanted signals into the input stages, in this case involving Q1 & Q2.

So we have tried to cancel these fields as much as possible (in a single sided PC board).

For example, notice how the positive fuseholder (F1) is placed close and parallel to the emitter resistors for Q10 & Q12. So what happens is that the magnetic field produced by the asymmetric current in fuse F1 is more or less cancelled as the same current flows back in the emitter resistors. This is the main reason why the layouts for these two modules is much tighter than our designs of recent years.

You will see the same method employed in the Version 1 of the board, with the heavy collector and emitter tracks placed close together but we think this has been more fortuitous on Version 2 than on Version 1.

It is then most important to arrange the DC supply cables to the amplifier to further this cancellation process. We'll detail this in the construction description.

To make the input stage less vulnerable to spurious magnetic fields from the output stage, we have concentrated it into as small an area of the PC board as possible.

Another trick is the location of the takeoff point for the 22kΩ resistor and its orientation at rightangles to the output stage emitter resistors.

Finally, the signal earth for the input stage is separated from the main amplifier earth by a 10Ω resistor.

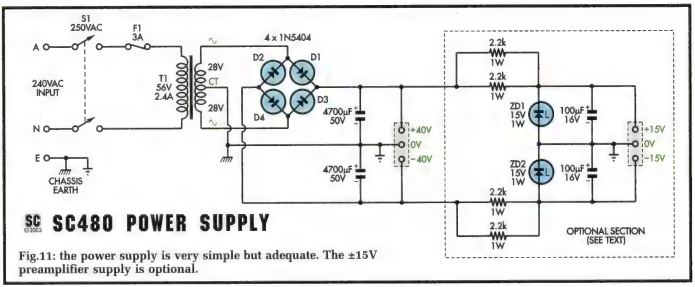


Fig.11: the power supply is very simple but adequate. The ±15V preamplifier supply is optional.

This is not so important when a single module is in use but it is most important when two modules are used in a stereo system.

In that situation, the joining of the two signal earths back via the input cables to a single program source such as a CD player will cause an earth loop and a resulting major degradation in the separation between channels and lesser degradation in the distortion performance.

Well, that's probably enough discussion of the PC board but suffice to say that the overall design has been carefully arranged to minimise distortion and leave as little to chance in the wiring layout so that constructors are certain to get excellent results.

Next month, we'll give the full details of assembly, wiring and setup of both versions, the parts list and the PC board patterns. **SC**

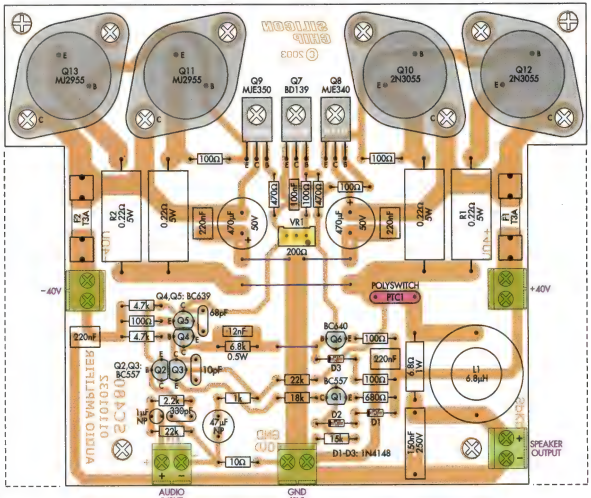


Fig.12: version 2 of the SC480 amplifier with the TO-3 (steel) transistors. We'll be presenting this again next month as par of the constructional details but it is reproduced here to demonstrate the attention we have paid to the PC board design to achieve the exceptional performance figures depicted on earlier pages.

A "Tiptronic-style" Gear Indicator

Do you know what gear your car is in at any given time? "Just look at the gear stick", you say. Actually, it's not that easy, especially if you have a 4-speed automatic or a 5 or 6-speed manual gearbox. And what if you ride a motorbike? So you need the Gear Indicator – it will give you the answer on a digital readout.

By JOHN CLARKE

IF YOU'RE DRIVING in traffic, it is quite easy to be in the wrong gear, especially as the noise of the traffic can drown out the engine. And if you have your stereo system blaring as well, then what chance have you got? Yes, you can deliberately look at the gearstick but you're not likely to do that unless you suspect you might be in the wrong gear.

Why would you be in the "wrong gear" in the first place? If your car is stuck in heavy traffic you might easily continue on for some time in 2nd or 3rd after the traffic clears, particularly if your engine is not noisy.

Much the same can happen with an automatic, if you are in the habit of "flicking" back to 3rd or 2nd (eg, when going up a hill or for engine braking downhill). It's all too easy to forget to flick it back into Drive later on. As a result, you could finish up driving quite some distance in a low gear and that's not good for fuel consumption.

The same problem can happen if you ride a motorbike. Wouldn't it be nice to have a digital display to show the gear you're in? In fact, when driving an automatic it can still be useful to know which gear you are in, even if Drive is correctly selected. Modern automatics are so smooth that it can be difficult to "pick" the changes. Now you can "see" what the transmission is doing.

This idea is not new, of course. All cars with Tiptronic transmissions and the latest Honda Jazz with its 7-speed gearbox have a digital gear indicator on the dashboard.

Main features

Basically, the Gear Indicator con-

sists a small box which incorporates a single-digit LED display. This can show gear selections from 1-9, Neutral (which is shown on the display as a dash; ie, "-") and Reverse (which is shown as an "r").

Inside the case are several switches which allow the unit to be calibrated and set up for best gear detection results. Once it's all set up, that's it – there are no user controls on the front panel to fiddle with.

As presented, the unit is designed to be mounted on the dashboard. Alternatively, you could hide the unit under the dashboard and mount the LED display separately, if space is a problem. A 9-strand cable (eg, rainbow cable) would then be required to connect the display back to the main circuit.

The right gear

The Gear Indicator works by monitoring both the speed of the vehicle and the engine RPM. It then decides which gear has been selected by feeding the results into a lookup table that's programmed into an internal microcontroller. And that means that the unit must first be calibrated, so that it knows what the results are for each gear.

Note, however, that neutral (-) is always shown when the unit is first powered up and also if the vehicle is stationary (or almost stationary) while the engine is running. By contrast, reverse (r) is shown when ever the vehicle's reversing lights are activated.

One thing you should note is that the Gear Indicator does not work by detecting gear changes – eg, by fitting switch actuators to the gearstick. This method would not only be unreliable but would also be a mechanical nightmare to set up. What's more, the position of the gear selector in an automatic car doesn't tell you which gear the transmission is in (unless 1st gear is manually selected).

That's because the transmission can still select any one of the lower gears in the remaining positions. For example, if the gear selector is set to 3rd, 2nd and 1st can also be selected.

Of course, it is conceivable that the signals from an electronically controlled automatic transmission could be used to drive a gear display. However, we have not provided for this in the Gear Indicator because these signals would be different on each type of vehicle and may be difficult to utilise effectively.

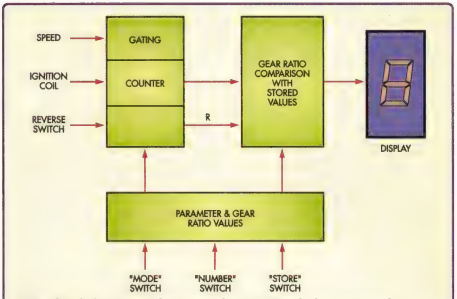


Fig.1: block diagram of the Gear Indicator. It works by counting the number of ignition pulses that occur during a fixed number of pulses from a speed sensor and comparing the result with a "lookup" table that's stored in memory.

Block diagram

Fig.1 shows the basic operation of the Gear Indicator. There are three external inputs: speed sensor pulses, ignition coil pulses and the reversing switch input.

The speed sensor pulses can be obtained from a rotating magnet and coil assembly mounted on the tailshaft. Alternatively, you can use the digital speed signal that comes from the vehicle's engine computer, if this can be identified (and accessed). The ignition pulses can either be obtained from the ignition coil or you can use the low-voltage tachometer signal from the engine management computer if this is available.

The reversing input is obtained, naturally enough, from the reversing switch. When this switch is closed (ie, when reverse gear is selected), the display will show an "r" for reverse as indicated previously. Conversely, when the switch is open, the display will show either neutral (when the unit is first powered up or if there are no pulses) or a gear number.

If the vehicle is moving, the circuit counts the number of ignition coil pulses that occur during a fixed number of speed pulses. If a low gear is selected (eg, 1st gear), it follows that there will be more ignition pulses counted for a given speed compared to those counted at the same speed in a higher gear.

The gear selection number is shown on the 7-segment LED display. This number is obtained by comparing the number of ignition pulses counted with the stored values (in a microcontroller). These stored values are obtained during calibration of the Gear Indicator.

Fig.2 shows how the Gear Indicator compares the ignition pulse counts with the calibration values. These calibration values are different for each gear and are obtained by driving the vehicle in each gear during the initial setup.

This means that comparing the counted pulses with the calibration values should give the correct gear number. However, in practice, the calibration number may differ from the value obtained during driving. That's because the number of ignition pulses counted may vary by up to several counts for the same number of speed pulses, depending on the phase difference between the two.

To counter this effect, a set amount of hysteresis is added to each gear range – see Fig.2. This can be varied to suit the vehicle during calibration and also corrects for any slippage in the transmission – either in the clutch or in the torque converter.

As a further refinement, a slight

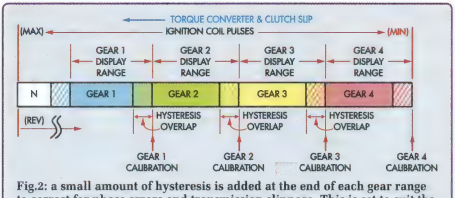


Fig.2: a small amount of hysteresis is added at the end of each gear range to correct for phase errors and transmission slippage. This is set to suit the vehicle and is one of several parameters that are adjusted during the setup procedure.

delay is added between each display update. This delay prevents the display from behaving erratically during gear changes, when clutch slippage and changes in engine RPM could otherwise produce an incorrect gear indication.

Circuit details

Refer now to Fig.3 for the circuit details. As indicated above, it's based on a PIC microcontroller (IC1). This device accepts inputs from the various sensors and switches and drives the 7-segment LED display.

OK, let's start with the speed sensor circuit. This consists of a sensing coil which mounts on the chassis, plus four magnets which mount on a drive shaft (or tail shaft). As the magnets spin past, they induce a voltage into the coil and this is detected by comparator stage IC3.

One side of the speed sensing coil connects to a 2.5V supply, derived from a voltage divider consisting of two 2.2kΩ resistors between the +5V rail and ground. This 2.5V rail is decoupled using a 47µF capacitor and biases pin 3 (the non-inverting input) of IC3 via a 22kΩ resistor. It also biases pin 2 of IC3 via the coil and a series 1kΩ resistor. Diodes D1 & D2 clamp the input signal from the coil to 0.6V, while the associated 10nF capacitor filters the pickup signal.

IC3 is wired as an inverting Schmitt trigger comparator. Its hysteresis is set by a 1MΩ positive feedback resistor, which prevents false triggering due to noise.

The output signal from the speed sensor is a 250mV peak-to-peak pulse waveform and this is fed to pin 2 of IC3. Each time the input swings negative, IC3's output (pin 1) goes high (ie, to about 10V).

This output is fed to pin 12 (RB6) of IC1 via a 3.3kΩ current limiting resistor. The internal diodes at RB6 then clamp the signal voltage to about 5.6V. Note that the feedback signal for IC3 is derived from this point to ensure a consistent hysteresis level, regardless of the 12V supply level.

Ignition coil pulses

As shown, signals from the ignition coil are first fed to a voltage divider consisting of 22kΩ and 10kΩ resistors. The associated 68nF capacitor then shunts any signals above 700Hz to ground to eliminate noise.

From there, the signal is AC-coupled via a 1µF capacitor to diode D3 and thence to pin 2 of op amp IC2a. Zener diode ZD2 limits the signal amplitude at D3's anode to 20V, while D3 prevents negative signals from being fed into IC2a. The associated 10kΩ resistor pulls pin 2 low in the absence of a signal input via D3.

A low input (LOW IN) has also been provided at the junction of D3 and ZD2. This input allows the tachometer signal from an engine management computer to be applied instead of using the ignition coil input. The signal level at this input can be anywhere from 2.3V up to a maximum of 20V.

IC2a is wired as an inverting comparator with hysteresis. Its pin 3 input is nominally biased to about 1.6V via a voltage divider connected to the 5V rail, while the 47kΩ feedback resistor provides the hysteresis to set the high and low trigger points (1.7V and 1.5V respectively).

The resulting square-wave signal at IC2a's output is fed to pin 6 of IC1 via a 3.3kΩ resistor. The signal on pin 6 is then clamped by pin 6 (via internal diodes) to 0.6V above IC1's supply rail (5V), as before.

In operation, IC1's pin 6 input is set as an interrupt – ie, the microcontroller's embedded software increments the count each time pin 6 goes low.

Display brightness

Trimpot VR1, light dependent resistor LDR1 and op amp IC2b are used to control the display brightness. As shown, IC2b is connected as a voltage follower and this drives buffer transistor Q1 (which is inside the negative feedback loop) to control the voltage applied to the anode of the 7-segment LED display.

When the ambient light level is high, LDR1 has low resistance and so the voltage on pin 5 is close to the +5V supply rail. As a result, the voltage on Q1's emitter will also be close to +5V and so the display will operate at full brilliance.

As the light level falls, the resistance of the LDR increases and the voltage on pin 5 of IC2b decreases. As a result, Q1's emitter voltage also falls and so the display operates with reduced brightness.

When it's completely dark, the LDR's resistance is very high and the voltage on pin 5 of IC2b is determined solely by VR1. This trimpot is adjusted to give a comfortable display brightness at night.

The 7-segment LED display is driven via the RA1, RB1-RB5 and RB7 outputs of IC1 via 470Ω resistors. A low output on any one of these output lines lights the corresponding display segment, with the output at RA4 controlling the decimal point.

Switch inputs

Pushbutton switches S1, S2 and S3 are monitored using the RA2 and RA3 inputs. These two inputs are normally tied high via 10kΩ resistors and are only pulled low when the switches are pressed.

When S1 (Mode) is closed, RA2 is pulled low and this is recognised as a closed switch by the software. Similarly, when S2 (Number) is closed, RA3 is pulled low, while pressing S3 (Store) pulls both RA2 & RA3 low to ground (via diodes D4 & D5). As a result, the software can recognise

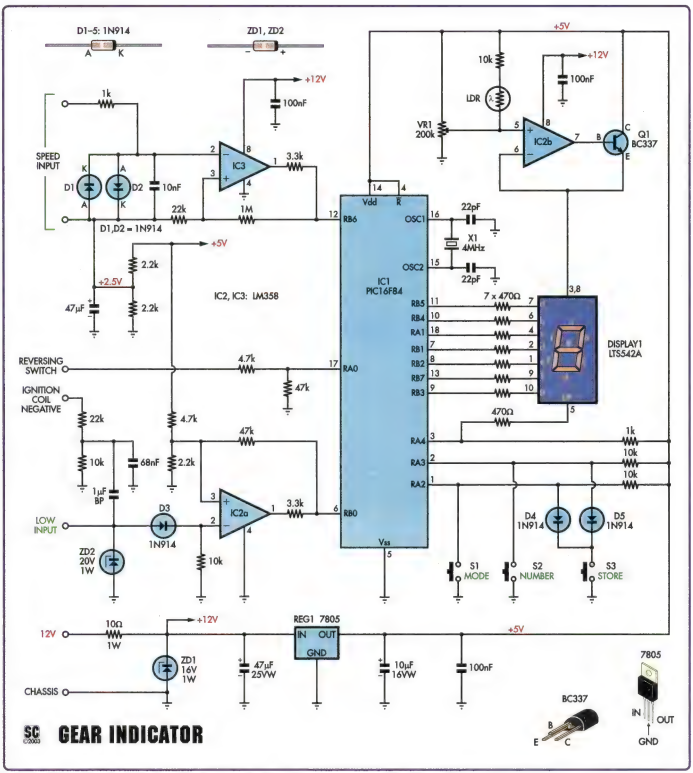


Fig.3: the complete circuit of the Gear Indicator. The PIC microcontroller (IC1) processes the signals from the various inputs and drives a single 7-segment LED display (DISPLAY1) to show the result. IC2b, Q1 & LDR1 automatically dim the display at night, so it is not too bright.

which switch has been pressed and respond accordingly.

Clock signals

Clock signals for IC1 are provided by an internal oscillator and a 4MHz crystal (X1) connected between pins 15 & 16. The two associated 22pF capacitors are there to provide the correct loading and to ensure that the oscillator starts reliably.

The crystal frequency is divided down internally to produce clock signals for the internal circuitry and the various parameters used in the software. It is also used to give a precise time period to count the speed pulses.

Power

Power for the circuit is derived from the vehicle's battery via a fuse and the ignition switch. This supply line is

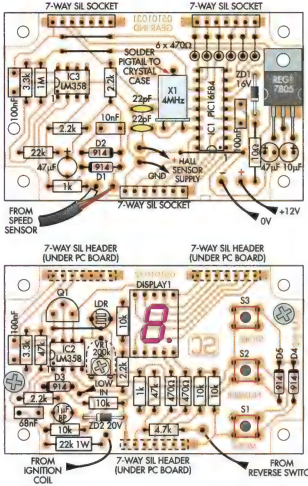


Fig.4: install the parts on the two PC boards as shown here. Note that all the electrolytic capacitors must be mounted so that their bodies lie parallel to the board surfaces (see photos), so that the boards can later be stacked together.

decoupled using a 10Ω 1W resistor and filtered using a 47µF electrolytic capacitor. ZD1 provides transient protection by limiting any spike voltages to 16V. It also provides reverse polarity protection – if the supply leads are reversed, ZD1 conducts heavily and "blows" the 10Ω resistor.

The decoupled supply is fed to 3-terminal regulator REG1 to derive a +5V rail. This rail is then filtered using 10µF and 100nF capacitors and used to power IC1. IC2 and IC3 derive their power directly from the decoupled +12V rail.

Table 2: Capacitor Codes

Value	IEC Code	EIA Code
100nF (0.1µF)	100n	104
68nF (.068µF)	68n	683
10nF (.01µF)	10n	103
22pF (22p)	22p	22

Construction

Fig.4 shows the assembly details. Most of the work involves building two PC boards: a microcontroller board coded 05101031 and a display board coded 05101032. These two boards are then stacked together piggyback fashion using pin headers and cut down IC sockets, so that there is very little external wiring.

Begin by carefully checking the PC boards for defects, by comparing them with the published patterns. It's rare to find problems these days but it doesn't hurt to make sure.

The microcontroller board can be assembled first. Install the three wire links first, then follow with the resistors and diodes. Table 1 shows the resistor colour codes but we also recommend that you check each value using a digital multimeter as some colours can be hard to decipher.

Note that the six 470Ω resistors are mounted end-on to save space. Take care when installing D1 & D2 as they face in opposite directions. Similarly, watch the orientation of ZD1.

REG1 can go in next. It is mounted with its metal tab flat against the PC board. As shown, its leads are bent

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	1MΩ	brown black green brown	brown black black yellow brown
❑	2	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	2	22kΩ	red red orange brown	red red black red brown
❑	5	10kΩ	brown black orange brown	brown black black red brown
❑	2	3.3kΩ	orange orange red brown	orange orange black brown brown
❑	3	2.2kΩ	red red red brown	red red black brown brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	7	470Ω	yellow violet brown brown	yellow violet black black brown
❑	1	10Ω	brown black black brown	N/A

down at right angles so that they pass through their respective mounting holes. This is best done by slipping an M3 screw through the hole in the device tab, positioning it on the PC board and then gripping one of the leads with a pair of needle-nose pliers, just before it reaches the mounting hole. The device is then lifted clear of the PC board and the lead bent down at right angles, after which the procedure is repeated for the next lead.

Next, install a socket for IC1, taking care to ensure that it is the right way around. Don't plug the microcontroller in yet – that step comes later, after you've checked out the power supply. IC3 can then be installed, followed by the capacitors.

Note that the 47µF capacitor near the speed sensor input must be installed so that it lies parallel with the PC board – see photo. Similarly, the adjacent 47µF & 10µF capacitors below REG1 lie over the regulator's leads. In each case, it's simply a matter of bending the capacitor's leads at right angles before installing it on the PC board.

Crystal X1 mounts horizontally on the PC board and can go in either way around. It is secured by soldering a short length of wire between one end of its case and an adjacent PC pad.

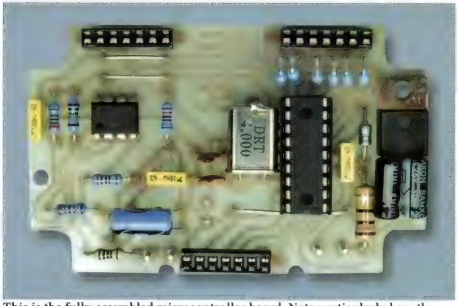
Finally, you can complete the assembly of this board by fitting PC stakes to the external wiring points and fitting the 7-way single in-line (SIL) sockets. The latter are made by cutting down two 14-pin IC sockets into in-line strips using a sharp knife or fine-toothed hacksaw.

Clean up any rough edges with a file before installing them on the PC board.

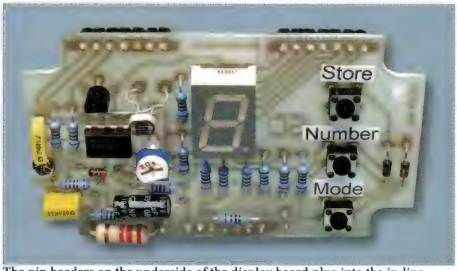
Before plugging in IC1, it's a good idea to check the supply rails (note: you don't need to have the display board connected to do this). All you have to do is connect a 12V supply to the board and check that there is +5V on pins 4 & 14 of the socket (use the metal tab of REG1 for the ground connection). If this is correct, plug IC1 in as shown in Fig.4 – ie, pin 1 towards bottom right.

Display board

Now for the display board. Install the wire link first, followed by the resistors, diodes D3-D5, ZD2 and transistor Q1. The three capacitors can then be installed, along with trimpot



This is the fully-assembled microcontroller board. Note particularly how the three electrolytic capacitors are mounted – ie, so that they lie horizontally across other components.



The pin headers on the underside of the display board plug into the in-line sockets on the microcontroller board. Take care to ensure that the 7-segment LED display is correctly oriented.

VR1 and the 7-segment LED display. Note that the 1µF bipolar capacitor is installed so that it lies across ZD2 – see photo.

Watch the orientation of the LED display – its decimal point goes towards bottom right.

LDR1 can go in next. It's mounted so that its top face is about 3mm above the face of the 7-segment display. Once it's in, you can install switches S1-S3 and PC stakes at the external wiring points.

The three 7-way SIL pin headers are installed on the copper side of the PC board with their leads just protruding above the top surface. You will need a fine-tipped soldering iron to install them. Note that you will have to slide the plastic spacers along the pins to allow room for soldering, after which the spacers are pushed back down again.

Final assembly

Work can now begin on the plastic case. First, remove the integral side pillars with a sharp chisel, then slide the microcontroller board into place. That done, mark out the two mounting holes – one aligned with the hole in REG1's metal tab and the other diagonally opposite on the lefthand side.

Now remove the board and drill

Parts List

1 microcontroller PC board, code 05101031, 78 x 50mm
1 display PC board, code 05101032, 78 x 50mm
1 plastic utility case, 83 x 54 x 30mm
1 dark red transparent Perspex or Acrylic sheet, 14 x 16 x 2.5mm
1 4MHz parallel resonant crystal (X1)
1 LDR (Jaycar RD-3480 or equivalent)
4 or 6 button magnets
1 coil former, 15mm OD, 8mm ID x 7mm
1 20m length of 0.18mm enamelled copper wire
1 6mm x 25mm steel bolt, 2 washers and nut
6 PC stakes
3 7-way pin head launcher
2 DIP-14 low-cost IC socket with wiper contacts (cut for 3 x 7-way single in-line sockets)
3 PC-mount tactile membrane switches (S1-S3) (Altronics S 1120 or equivalent)
2 6mm long M3 tapped spacers
1 10mm Nylon spacer or 2 x 6mm spacers with one cut to 4mm
1 9mm long untapped metal spacer
2 M3 x 6mm countersunk screws
2 M3 x 15mm brass screws
1 400mm length of 0.8mm tinned copper wire
1 2m length of single core shielded cable
1 2m length of 7.5A mains rated wire
1 2m length of red automotive wire
1 2m length of black or green automotive wire (ground wire)
1 2m length of white automotive wire
1 200kΩ horizontal trimpot (VR1)

Semiconductors
1 PIC16F84P microprocessor programmed with gear.hex (IC1)
2 LM358 dual op amps (IC2,IC3)
1 7805, LM340T5 5V 1A 3-terminal regulator (REG1)
1 BC337 NPN transistor (Q1)
1 HDSP5301, LTS542A common anode 7-segment LED display (DISP1)
5 1N914, 1N4148 signal diodes (D1-D5)
1 16V 1W zener diode (ZD1)
1 20V 1W zener diode (ZD2)

Capacitors
2 47μF 25VW PC electrolytic
1 10μF 16VW PC electrolytic
1 1μF bipolar electrolytic
3 100nF MKT polyester
1 68nF MKT polyester
1 10nF MKT polyester
2 22pF ceramic

Resistors (0.25W 1%)

1 1MΩ	2 3.3kΩ
2 47kΩ	3 2.2kΩ
1 22kΩ	2 1kΩ
1 22kΩ 1W	7 470Ω
5 10kΩ	1 10Ω 1W

Alternative speed sensor
1 PC board, code 05101033, 14 x 30mm.
1 UGN3503 Hall senosr
1 100nF MKT polyester capacitor
1 2m length of twin-core shielded cable
3 PC stakes

Miscellaneous
Automotive connectors, heatshrink tubing, aluminium bracket, self-tapping screws

these two holes to 3mm. Once drilled, they can be slightly countersunk on the outside of the case to suit the mounting screws.

In addition, you will have to drill two holes in the back of the case to accept the power leads, the shielded cable from the speed sensor, the ignition coil and the reversing switch. These holes should be located so that they line up with the relevant PC stakes.

The display board can now be plugged into the microcontroller board and the assembly fastened together and installed in the case as shown in Fig.5. Once it's all together, check that none of the leads on the display board short against any of the parts on the microcontroller board. Some of the pigtails on the display board may have to be trimmed to prevent this.

The panel artwork can now be used as a template for marking out and drilling the front panel. You will need to drill a hole for the LDR plus a series of small holes around the inside perimeter of the display cutout.

Once the holes for the display cutout have been drilled, knock out the centre-piece and clean up the rough edges using a small file. Make the cutout just big enough so that the red Perspex is a tight fit. A few spots of superglue along the inside edges can be used to ensure that the window stays put.

That done, you can affix the front panel label and cut out the holes with a utility knife.

Testing

Now for the smoke test! First, apply power and check that the display shows "-". If it doesn't, switch off immediately and check for wiring errors and solder faults.

Assuming that everything is OK, you can test the dimming feature by holding your finger over the LDR. Adjust VR1 until the display dims to the level you want at night.

Next, connect the leads from the ignition coil (or low level input), the reversing switch and the speed sensor. These leads all connect to the underside of the PC board and the ignition and reversing switch wires pass through to the base of the case via notches cut in the side of the microcontroller PC board. These notches are located on either side of the adjacent 7-way socket and their positions are marked on the PC board using a fine track outline.

Speed sensor

Two different speed sensors can be made up, one based on a coil pickup and the other using a Hall sensor pickup. However, both rely on the use of an adjacent rotating magnet assembly .

The coil pickup is likely to be more rugged and less prone to water damage but the Hall sensor will allow for very low speed operation. That's because its output voltage doesn't depend on the speed at which the magnets rotate past the sensor. It's just a matter of waterproofing it correctly,

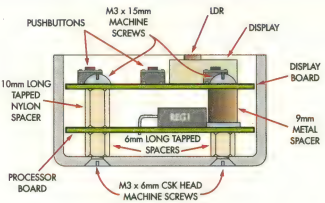


Fig.5: this diagram shows how the two PC boards are stacked together and secured to the bottom of the case using screws, nuts and spacers. Be sure to use nylon spacers where specified.

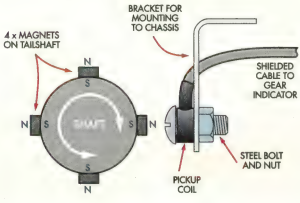


Fig.6: the pickup coil used in the speed sensor is mounted on a L-shaped bracket that's secured to the vehicle's chassis. Position the coil so that it is no more than 10mm away from the magnets as they pass, to ensure sufficient signal pickup. Note that the magnets must all be installed with the same pole facing outwards – either North as shown here or South.

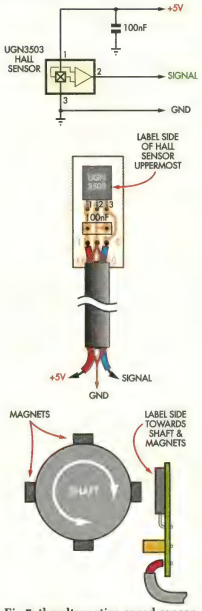
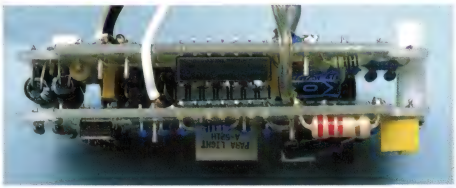


Fig.7: the alternative speed sensor uses a Hall effect device mounted on a small PC board.

using heatshrink tubing and silicone sealant.

The coil sensor version is shown in Fig.6. It is made by winding about 400 turns of 0.18mm enamelled copper wire onto a plastic bobbin measuring 15mm OD x 8mm ID x 5mm. Use electrical tape to secure the turns and leave about 10-20mm of lead length at each end.

Once the coil has been wound, solder its leads to a suitable length of shielded cable – ie, one lead goes to the shield wire and the other goes to the core. Secure this lead to the side of the coil with some tape, then cover



This is the completed PC board assembly, ready for mounting in the plastic case. Note that the various external leads are all soldered to PC stakes on the copper side of each board, with the leads from the display board resting in small grooves cut into the microcontroller board.

Adjustable Parameters For The Gear Indicator

Because each vehicle is different, the Gear Indicator requires correct setup to obtain the best results. Consequently, the unit has been designed to cater for up to nine gears and there are various parameters that can be adjusted to control its operation.

Table 3 shows the details of the various parameters. These are as follows:

(1) The first parameter that can be set is the number of speed pulses used to gate the ignition pulses. This is adjustable from 4-36 pulses in increments of 4, using numbers from 1-9. The initial setting is for 12 pulses but this may have to be varied to cater for various speed sensor characteristics.

(2) Next is the amount of hysteresis for each gear comparison. In practice, this value is made just large enough so that the display does not sometimes briefly show the next highest gear number. The default value is 6% of the ignition pulse count and this should be suitable in most cases.

This value will have to be increased if the display shows a tendency to occasionally jump to the next highest gear. Conversely, it should be made lower if this tendency is not apparent and then adjusted back the other way until the effect disappears.

In practice, you can adjust the hysteresis over a range from 2-20%. The lower the value the better, since this gives the greatest range of ignition pulses that are counted for each gear.

The third parameter is the delay between gear changes. Without this delay, the display could show the incorrect number since the engine RPM can vary widely when changing gears.

The initial setting for this is 0.2s which should be suitable for most cars. However, depending on the driver, the 0.1s setting may be better for cars with manual gearboxes. Conversely, a longer delay may be needed for cars with automatic transmissions.

You can set the delay to any value between 0.1s and 0.9s.

The fourth parameter is the timeout

Table 3: Adjustable Parameters

Display Value	Speed Pulses (S)	Hysteresis	Delay (d)	Timeout (-)	Reverse (r)	Clear (C)
1	4	2%	0.1s	0.5s	12V = r*	-
2	8	4%	0.2s*	1s	0V = r	-
3	12*	6%	0.3s	1.5s	12V = r*	-
4	16	8%	0.4s	2s	0V = r	-
5	20	10%	0.5s	2.5s*	12V = r*	-
6	24	12%	0.6s	3s	0V = r	-
7	28	14%	0.7s	3.5s	12V = r*	-
8	32	17%	0.8s	4s	0V = r	-
9	36	20%	0.9s	4.5s	12V = r*	-

Note: an asterisk (*) denotes the default value.

the coil with silicone sealant (preferably the non-acid type such as roof and gutter sealant). Finally, cover the coil with a short length of heatshrink tubing and shrink it into place using a hot-air gun

The sealant should now be left to dry for about eight hours. A 100mm-long cable tie can be placed around the coil to secure the lead in place.

The alternative Hall sensor is assembled on a small PC board coded 05101033. Fig.7 shows the assembly details. Apart from the Hall sensor itself, there's just a single 100nF capacitor to be installed.

Note that the UGN3503 Hall sensor is mounted flat against the PC board with the label side up. The connecting lead to the main unit is run using twin-core shielded cable.

Installation

Be sure to use automotive cable and connectors when installing the unit into a vehicle. The +12V supply is derived via the ignition switch and the fusebox will provide a suitable connection point. Be sure to choose the fused side of the supply rail, so that the existing fuse is in series.

You should also be able to access the reversing switch connection at the fusebox. The ground connection can be made by connecting the lead to the chassis using a solder eyelet and self-tapping screw.

Fig.6 shows the mounting details for the speed sensor. **Note that the four magnets must all be installed with the same pole facing outwards** – ie, they must all have either their north pole facing outwards or their south pole facing outwards (it doesn't matter which).

This is done by attaching the magnets together in a stack. This will either give an N-S-N-S, etc stack or an S-N-S-N, etc stack. You then mark the outside face of the top magnet and remove it from the stack, then mark the next magnet and remove it and so on until all the magnets are separate. The magnets can then be attached to the driveshaft with the marked faces on the outside.

The magnets should be equally spaced around the driveshaft and can be affixed using builder's adhesive (eg, Liquid Nails, Max Bond, etc). Covering the magnets with some neutral cure silicone sealant will protect them from damage due to stones and other debris thrown up by the wheels.

The pickup coil can be secured by bolting it to an L-shaped bracket which is then fastened to the chassis. Position it so that there is about a 10mm maximum gap between it and the magnets as they pass.

Alternatively, you can use a Hall sensor instead of the pickup coil, as

period. Normally, the ignition pulses are counted during a set number of speed pulses. However, if the vehicle is moving very slowly or is stopped, the speed pulses may not reach the count setting. Instead, the timeout stops the count and places a neutral (-) reading on the display.

The timeout parameter is initially set at 2.5s but can be set anywhere in the range from 0.5-4.5s, using numbers from 1-9. Its setting is a compromise between showing neutral only when stopped or at a very low speed (long timeout) and getting a fast neutral indication after coming to a stop (short timeout).

The next parameter is the reversing switch sense. Setting an odd number between 1 and 9 (1, 3, 5, 7 or 9) will cause the display to show reverse when the reverse input goes to +12V. Conversely, setting an even number (2, 4, 6 or 8) will cause reverse to show when the reverse input goes to 0V.

This selection is simply made so that the unit shows reverse ("r") when the reversing lights come on.

The final parameter is "clear", which clears all the gear calibration values. The gear ranges will then need to be recalibrated. This "clear" operation should be carried out if the unit is fitted into another vehicle.

shown in Fig.7.

The ignition coil input is connected directly to the switched (negative) side of the ignition coil using a 250VAC rated cable.

Using computer signals

As mentioned earlier, instead of making you own speed sensor, you may be able to obtain the speed signal from the engine management computer. This signal is simply fed to the 1kΩ resistor at the speed input.

If the car's speedometer stops operating after connecting the Gear Indicator, increase the 1kΩ resistor on the speed input to 10kΩ and remove the 10nF capacitor.

Similarly, you can use the low-voltage tachometer signal from the computer instead of ignition coil pulses if this is available. In fact, it will be necessary to do this if your car uses several double-ended coils to fire the

Setting The Parameters

The various parameters are set by first pressing (and holding down) the Mode switch while the Gear Indicator is powered up. The display decimal point then lights to indicate that the unit is in the "setting mode".

The first parameter shown is an "S" which refers to the speed pulses. If the Mode switch is then released, the display will show the value stored (from 1-9) after 1s. Conversely, if the Mode switch is held down, the other parameter indicators will appear in succession, at a 1s rate.

The parameter values are altered by pressing the Number switch. Each press increments the number by one, while holding the Number button down causes the value to automatically increase at a 1s rate – ie, the numbers cycle from 1-9 and then back to 1 again. When the required value is selected, you simply release the Number switch and press the Store switch to store the value in memory.

Once the "S" (speed) parameter has been set, the other parameters are selected and set in turn. These are "H" (hysteresis; "d" (delay); "-" (timeout) and "r" (reverse). These are all modified and stored exactly as before.

Note that no changes are stored until the Store switch is pressed. This enables you to cycle through the parameters to check their values without making any changes.

The last parameter to be selected simply shows a "C" on the display, without any value. Pressing Store will clear all the gear settings.

Finally, you exit from the Parameter Mode, by switching off and then reapplying power. The display will then show a "-" (ie, the neutral gear indication) and the decimal point will be off.

Gear Calibration

Pressing the Mode switch after the unit has powered up places the unit into the "Calibrate Mode". The decimal point will light to indicate this mode and the number shown initially will be a "1" (ie, 1st gear).

To calibrate the unit, just follow these step-by-step instructions:

(1) Drive the vehicle at light throttle with 1st gear selected (for automatics, you have to select 1st gear rather than Drive). After a few seconds, press the Store button and the calibration for 1st gear is saved.

Note that it may be necessary to drive relatively fast in 1st gear to ensure that the speed pulses are counted within the timeout period. Also, with an automatic, be sure to drive along a flat section of road without accelerating to eliminate torque converter slip.

(2) Next, press the Number button so that the unit shows a "2" (ie, 2nd gear). Now drive at light throttle in 2nd gear for a few seconds and press the Store switch to calibrate the 2nd gear.

Note that it is not necessary to drive at a fast speed in this gear to achieve calibration. If the car is an automatic, be sure to select 2nd gear and drive fast enough to ensure that the car is in this gear (ie, not 1st).

The remaining gears are calibrated in exactly the same manner.

(3) Once you have calibrated all the gears, press the Mode switch again and the decimal point will extinguish. The unit will now revert to the "Gear Indicator" mode.

If you make a mistake during the calibration, or if the unit is to be used in a different vehicle, the stored data should be cleared using the "C" parameter before re-calibrating the unit.

Note too that if you subsequently change the speed pulses parameter after calibration, the gears will need to be recalibrated. Also, if you don't obtain a successful 1st gear calibration, this gear can be recalibrated after extending the timeout delay. In that case, the Store button should be pressed after about 10 seconds to ensure a suitable count for the ignition pulses.

Note that some automatics start in 2nd gear rather than 1st when light throttle settings are used.

Fig.8: this full-size artwork can be used as a drilling template for the front panel. You will need to make cutouts for the LDR and the 2-segment LED display.

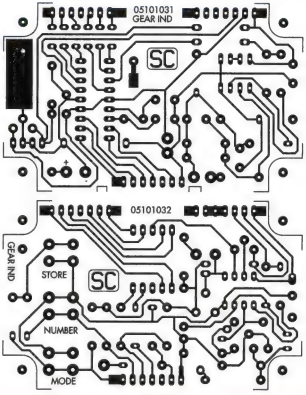


Fig.9 (right): check your etched PC boards against these full-size patterns before any of installing the parts. The smallest board (ie, 05101033) is for the optional Hall speed sensor.

spark plugs, rather than a single coil.

The low-voltage tachometer signal should be applied to the low input terminal on the Gear Indicator (not to the ignition coil terminal).

On-road testing

Once fitted to the vehicle, the various parameters can be set and the unit calibrated as described in the accompanying panels.

The speed pulses setting for the parameters can be made a larger value as described earlier. This will give more ignition pulses to be counted and give a better resolution for the differences in counts for each gear ratio. The larger value will also provide less tendency to show a lower gear due to clutch or torque converter slippage.

The compromise is that the time required to count the pulses will be longer and the display will have a tendency to show the neutral (-) indication at a higher speed compared to using a smaller speed pulses number. This is because the timeout period will occur before the pulses are counted at slower speeds.

Gear change response will also be slower with a higher speed pulse count number.

In general, use 16 or more speed pulses if you use four magnets on the tailshaft and use 12 or less if you use magnets on the wheel shaft. Use of the speedometer sensor signal should require 28 or more speed pulses but may need to be smaller if the response at slow speeds is too long, causing neutral indication at not so slow speeds.

The corners of the two PC boards must be cut away to clear the mounting pillars inside the case. This should be done before any parts are installed.

Note also that using magnets and a coil pickup will not provide gear indication at very slow speeds since the output from the sensor will be too low to register. The Hall effect pickup will be much better at slow speeds and will provide gear indication down to where the speed pulse count takes longer than the timeout. **SC**

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Utilising a headset microphone for hands free operation, it is ideal for small PA applications such as in-store demonstrations, tour guides and lecturers etc. An auxiliary input also lets you play music from portable CDs and MP3 players to larger audience. A soft carry pouch with belt loop and waist strap is included. Runs on 6 x AAA rechargeable batteries which are supplied. **Professional quality.**

Cat. AM-4050 $139.95

Corrosion Buster Pen

The amazing spot cleaning brush tip is like a mini sandblaster pen with 20,000 fibres in the point to remove rust, wax & dirt from every nook & cranny without harsh chemicals.

NEW PRODUCT

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Handy 5 in 1 Pen

Not only is this a comfortable pen, it also has a PDA stylus, a powerful magnet built into the end as well as a small reversible Philips / slotted screwdriver under the end cap.

NEW PRODUCT

Cat. ST-3097 $14.95

Flashing LED Tie Pin

NEW PRODUCT

As tiny as it is, this fascinating device contains flashing LEDs and a battery to create an ever changing colour display. Use it as an avant-garde tie pin or even as a hi-tech fridge magnet that will really attract attention. You will never be missed in a crowd with this fascinating little beauty. Size approximately 10mm.

Cat. ST-3099 $3.95

3 LED & Xenon Globe & Cold Cathode Fluorescent (CCFL) Hand Torch

3 LED's for general use, a focusable Xenon for brighter light, and a CCFL for general ambient lighting. The torch is made from high impact plastic, with a rubber grip handle. It is water resistant and supplied with a nylon wrist strap.

NEW PRODUCT

Cat. ST-3079 $39.95

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A compact 12 volt strobe that is ideal for adding an additional deterrent on your car alarm.
Supplied with a blue lens, double sided fixing pad and mounting hardware.

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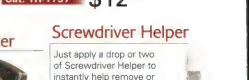
These precision spring loaded stainless steel electrical shears will cut soft wire up to 22sqmm and make light work of cable ties, heatshrink, light hook-up wire and cable braid etc.



Cat. TH-1757 $12.95

Bug Vacuum

A safe and effective way of relocating insects and creepy crawlies. They are sucked up into the tube, and can then be relocated to a suitable environment, without you having to touch them.

NEW PRODUCT

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Not your normal noisy "Bug-Zapper". This environmentally friendly bug killer attracts insects then sucks them into the internal containment system where they dehydrate and die. Dead insects are disposed through the removable tray.

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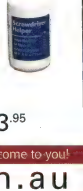
This digital compass is hand held or vehicle windscreen mounting, and supplied with both a lanyard and a suction mount base. The LCD display has an adjustable angle from flat for holding in the hand to vertical for windscreen mounting. The LCD also displays the time and temperature in either C or F.

NEW PRODUCT

Cat. QM-7262 $59.95

Screwdriver Helper

Just apply a drop or two of Screwdriver Helper to instantly help remove or tighten screws with stripped heads. This unique formula dramatically increases torque preventing your tool from slipping off a damaged screw head.



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Cat. AR-1762 $29.95

Pre Wired Switch/Fuse Assemblies

NEW PRODUCT

Horizontal Style

An attractive anodised facia plate with screen printed graphics. Pre wired to assist installation, the rocker switches are rated at 12VDC 10A. A 12V pilot light illuminates to indicate "on". Supplied with 23 stickers naming typical circuits (mainly for marine applications), mounting screws and a few 5A 3AG fuses are included.

4 Way Cat. SZ-1900 115x110mm $28.95
6 Way Cat. SZ-1901 115x168mm $37.95

Vertical Style

A heavy duty black bakelite plastic panel with pre wired 3 or 6way fuse/switch circuits. 10A chrome-brass SPST toggle wired through a conventional screw type 3AG fusehalder. A set of marine type stickers are supplied, along which black mounting screws and a couple of 5A, 3AG fuses.

4 Way Cat. SZ-1904 115x110mm $18.95
6 Way Cat. SZ-1905 115x110mm $26.95

Kingcell Alkaline Battery Bulk Packs

24 x AA

Our AA Kingcell's sell for 99c ea in a pack of 4, these are only 54c ea! Save 45c ea!

Cat. SB-2330 $12.95

24 x AAA

Our AAA Kincell's sell for $1.13ea in a pack of 2, these are only 54c ea! Save 45c ea!

Cat. SB-2331 $12.95

USB Flash Memory

NEW PRODUCT

One of the most portable storage devices yet! Simply plug into a USB port and you have a removable data storage medium. No drivers are required (except for Win 98/SE) Lightweight and portable. Ask in store for details.

32Mb $99.95 New Cat. XC-4763
64Mb $139.95 New Cat. XC-4764
128Mb $189.95 New Cat. XC-4765

Desktop Clock with Thermometer and Hygrometer

Featuring solid metal construction, with a stylish high quality Satin Nickel plating, these pieces will compliment any desktop or table. Fully analogue, they feature a 12Hr clock, a thermometer range of -30 to +60°C (-20 - 140°F), and a full range hygrometer (0 - 100% Humidity). Supplied in a metal case with a foam insert. Two sizes available.

Vertical

Vertically Standing: 85 x 28 x 10mm
Cat. XC-0240

Horizontal

Horizontally Standing : 117 x 36 x 13mm
Cat. XC-0242

NEW PRODUCT

BOTH SIZES $49.95ea

40 Channel UHF/CB Transceiver

- Open field range up to 5Km
- Inner City range up to 1Km
- VOX Function

Cat. DC-1010 $79.95

Hands Free VOX Kit to Suit Above

Cat. DC-1012 $14.95

Mains Charger to Suit Above

Cat. DC-1014 $14.95

12VDC/240VAC Pulse Mode NI-Cad & Ni-MH Smart Charger

- Efficient Pulse Mode Charging
- Fast Charging Time
- Extended Battery Life
- Reduced Memory Effect in Ni-Cad Cells
- Charges AA, AAA, C, D & 9V cells

Was $99.95 Save $15

Cat. MB-3511 Now $84.95

Multi Function Transfer Panel for PC's

NEW PRODUCT

This board transfers the USB, firewire, audio line In/Out, game port, and features a temperature probe and an infrared-IrDA connection. Installing the panel means you can quickly plug and unplug your peripherals from the front without climbing under tables. Supplied with all mounting and connecting hardware.

Cat. XC-5171 $99.95

SurfCam USB Web Camera

NEW PRODUCT

Use this Webcam in the office for Video Conferencing, or at home, to send pictures and video to your friends via email. It uses a 100K pixel colour CMOS sensor, with auto exposure and white balance for optimum performance under varying light conditions. Supplied with editing software.

Cat. QC-3220 $49.95

12VDC/240VAC 10 x AA or AAA Ni-Cad & Ni-MH Smart Charger

- Microprocessor Controlled
- Discharge Function
- Individual Status LED

Was $69.95 Save $15

Cat. MB-3512 $54.95

SB-2486

SB-2484

SB-2480 **SB-2482** **SB-2490**

1.3Ah	SB-2480	Was $24.95	Now $18.95	Save $6
2.2Ah	SB-2482	Was $32.95	Now $24.95	Save $8
4.2Ah	SB-2484	Was $39.50	Now $29.50	Save $10
7.2Ah	SB-2486	Was $39.95	Now $29.95	Save $10
18Ah	SB-2490	Was $88.95	Now $69.95	Save $19

12" Instrument / PA Speaker

NEW PRODUCT

- Nominal Impedance: 8 Ohms
- Power Handling: 100WRMS
- Frequency Range: 68Hz-3000Hz
- Sensitivity: 94dB 1W 1m

Cat. CG-2380 $99.50

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LCD Learning Remote Control 10 in 1

- Control up to 10 devices
- Multi language backlit LCD
- Up to 47 programmable Keys for each device

Was $129

SAVE $20

Cat. AR-1708 **Now $109.00**

RF Wireless Scroll Mouse

- No cables
- Reliable operation

Was $55

SAVE $10

Cat. XM-5120 **$45.00**

IEEE 1284 Compliant Printer Cables

D25 male to 36Pin Centronics male

2.0M
Was $22.50 Save $7.50
Cat. WC-7620 **$15.00**

5.0M
Was $31.50 Save $10
Cat. WC-7622 **$21.50**

D25 male to HPCN36 half pitch centronics 36 pin male

2.0M
Was $22.50 Save $7.50
Cat. WC-7628 **$15.00**

4 Port Powered USB Hub

- 4 downstream ports
- Full current supply to all ports

Was $54.95

SAVE $10

Cat. XC-4820 **$44.95**

14" Monitor Shelf

- Regain desk space
- Fits most monitors
- Max 5Kg load

Was $29.95

SAVE $10

Cat. XC-4640 **Now $19.95**

Easy Transfer Board for PCs and Macs

This board transfers the USB, Firewire, audio line in/out, and RS-232 ports to the ront of your computer. No more climbing under your computer desk.

Was $99.95

SAVE $20

Cat. XC-5170 **$79.95**

SCSI II Hard Disk Connecting Cable

HPDB50 male to HPDB50 male

1.0M
Was $33.50

SAVE $10

Cat. WC-7562 **$23.50**

CPU Cooler For AMD/Intel Processors

High speed 7000RPM cooling fan
- High efficiency heatsink
- 25% pure silver heatsink compound supplied

Cat. XC-5057 **$59.95**

Electronic Weather Forecaster with Alarm Clock & Calendar

- Large LCD display
- Humidity, temp, barometric pressure
- Regular calendar

Was $79.95

SAVE $20

Cat. XC-0299 **$59.95**

Blue 12" – 12Volt Neon Highlight

- Set of 2
- Mount separate or in stand
- Require 12VDC @ 400mA

Was $75.95

SAVE $16

Cat. ST-3134 **Now $59.95**

Mini Waterproof Camping Lantern

- Waterproof
- Floats in water
- Bright Krypton Globe

Was $16.95

SAVE $4

Cat. ST-3033 **$12.95**

Save on High Brightness LED's

3mm	(All are watercleat)					
Colour	**mCd**	**Norm**	**1+**	**10+**	**25+**	**Cat.**
RED	5000	$2.10	$1.80	$1.40	$1.10	ZD-1757
YELLOW	5000	$2.10	$1.80	$1.40	$1.10	ZD-1758
GREEN	3500	$3.95	$3.45	$3.05	$2.30	ZD-1991
BLUE	4000	$7.80	$6.80	$5.95	$4.75	ZD-1759

5mm	(All are watercleat)					
Colour	**mCd**	**Norm**	**1+**	**10+**	**25+**	**Cat.**
RED	6500	$1.60	$1.10	$0.95	$0.75	ZD-1777
YELLOW	5000	$1.25	$1.00	$0.90	$0.70	ZD-1778
GREEN	6000	$7.80	$5.95	$5.25	$4.15	ZD-1779
BLUE	3000	$3.50	$3.00	$2.60	$2.10	ZD-1999
WHITE	7000	$3.95	$3.45	$3.05	$2.30	ZD-1997

2 Computer / 1 Printer Auto Switch

- Automatic operation
- For IBM compatibles

Was $26.95

SAVE $7

Cat. XC-5088 **Now $19.95**

10Mbps PCI Combo Network Adaptor

- 32Bit NE2000 compatible
- RJ45 and BNC connections
- Plug n Play

Was $32.95

SAVE $5

Cat. YN-8060 **$27.95**

8 Port 10 Base-T Ethernet Hub

- 10Mbps transfer
- RJ45 connections
- Plugpack supplied

Was $99.95

SAVE $10

Cat. YN-8072 **$89.95**

9 Hour Digital Voice Recorder with USB Interface

- USB interface
- Editing software supplied
- 9 Hrs recording time
- 26(W)x110(H)x18(D)mm

Was $299

SAVE $20

Cat. XC-0282 **Now $279.00**

Ni-MH Power Bank for Digital Cameras

- Suits many popular cameras
- Built in charger
- 12V or mains charging
- High capacity 1800mAh

Was $99.95

SAVE $20

Cat. MP-3070 **Now $79.95**

20,000MCD Red LED

NEW PRODUCT
- 20,000MCD
- Waterclear Lens
- 5mm diameter

Cat. ZD-1790 **$3.95**

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Techstore Mail Order Specials

Available from Techstore Mailorders only. Limited stocks. See details below.

Power Saver Inverters

We have a limited quantity of ex-repaired inverters from our 2000 Catalogue. Now is the time to make some serious savings. All units have a 3 month warranty.

Cat. MI-5032

200W 12 to 230V
WAS $119.50 NOW $69 SAVE $50.50
Cat. MI-5032 6 Only

200W 24 to 230V
WAS $119.50 NOW $69 SAVE $50.50
Cat. MI-5033 7 Only

350W Sinewave 12 to 230V
WAS $349 NOW $229 SAVE $120
Cat. MI-5050 16 Only

750W Sinewave 12 to 230V
WAS $769 NOW $499 SAVE $270
Cat. MI-5055 9 Only

Cat. MI-5055

Ex-Repair Equator Car Alarm

Features code hopping, engine immobiliser, central locking control, LED warning and shock sensor. Two styles of remotes are available, though Jaycar reserves the right to supply what is left in stock. Cat. LA-8902

Type A

Type B

Type A
23 Only
WAS $189 NOW $119 SAVE $70

Type B
17 Only
WAS $189 NOW $119 SAVE $70

Ex-Repaired and Slightly Soiled Stock

All in good working order with 3 months warranty.

CCD 4-Way Auto Switcher

Cat. QC-3480

Switches between cameras or can stay on one.
WAS $149.50 NOW $89 SAVE $60.50
Cat. QC-3480 19 Only

150W Active Subwoofer Amp with Remote

350W into 4Ω
WAS $319 NOW $199 SAVE $120
Cat. AA-0500 28 Only

Cat. AA-0501

240W Active Subwoofer Amp with Remote

240W into 4Ω
WAS $329 NOW $219 SAVE $110
Cat. AA-0501 29 Only

350W Active Subwoofer Amp with Remote

350W into 4Ω
WAS $429 NOW $309 SAVE $120
Cat. AA-0508 5 Only

500WRMS 5 Channel Mosfet Car Amplifier

Cat. AA-0436

75WRMS x 4 + 200WRMS x 1 into 4 Ohms
110WRMS x 4 + 320WRMS x 1 into 2 Ohms
2001 Price $599 NOW $399 SAVE $16
Cat. AA-0436 15 Only

All prices in Australian dollars. These products are only available from Techstore & Mail Orders. Call them on 1800 022 888 or visit our website

www.jaycar.com.au

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RESPONSE Titanium Finish Subwoofers

- Vented coils
- Large rubber surround

10" Subwoofer – 125WRMS
Was $99 Save $15
Cat. CS-2274 **$84.00**

12" Subwoofer – 150WRMS
Was $129 Save $20
Cat. CS-2276 **$109.00**

RESPONSE XL Subwoofers

- Dual Voice Coil
- Double Magnets
- Polypropylene Cones

SAVE $20

10" XL Subwoofer – 200WRMS
Was $169
Cat. CS-2270 **$149.00**

12" XL Subwoofer – 200WRMS
Was $199
Cat. CS-2272 **$169.00**

SAVE $30

Philips Tweeter AD11610/T8

Famous Philips Tweeter Back Again. Direct import by Jaycar

- Frequency Range: 1K-22KHz
- Sensitivity: 95dB 1W 1M
- Nominal Impedance: 8 Ohms
- System Power: 100WRMS

NEW PRODUCT

Cat. CT-2012 **$26.95**

4 Door Power Door Locking Kit

- Universal Design
- Beware of inferior lower priced sets.
- Easy Installation

Was $59.95

SAVE $10

Cat. LR-8830 **Now $49.95**

JC-30 6" 2-Way Bookshelf Speaker Kit

- Outperform higher priced units
- Excellent Reproduction
- Suit all types of music
- Limited quantity

Buy a speaker kit and receive a FREE 30m roll of speaker cable. Cat. WB-1709 worth $19.95

Speaker and Crossover Kit - Pair
Cat. CS-2590 **$259.00**

Digital Monitor Headphones with Volume Control

- Adjustable Headband
- Inline Volume Control
- Precise Sound Reproduction

Was $45

SAVE $10

Cat. AA-2009 **Now $35.00**

JV60 Home Hi Fi Speaker Kits

- High Quality VIFA Drivers
- 100WRMS Power Handling
- PreBuilt, Pre-Finished MDF Cabinets

Limited quantity

Buy a complete kit and receive a FREE 20m roll of high quality monitor cable. Cat. WB-1736 worth $89.95

Speaker and Crossover Kit - Pair
Cat. CS-2560 **$569.00**

Pre-Built Cabinets – Pair
Cat. CS-2562 **$349.00**

Complete Kit – Pair
Cat. AA-0129 **$889.00**

Call into any Jaycar store for a demonstration. See cat page 230 for more details.

2 x 150WRMS Mosfet Car Amplifier

- Up to 450WRMS Bridged @ 4 Ohms
- Variable Crossover and Bass Boost
- Gold Plated Audio/Power Terminals

Was $335 Save $20

Cat. AA-0434 **Now $315.00**

4 x 100WRMS Mosfet Car Amplifier

- Up to 300WRMS x 2 Bridged @ 4 Ohms
- Variable Crossovers/Bass Boost
- Gold Plated Audio/Power Terminals

Was $449
Save $40

Cat. AA-0435 **Now $409.00**

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B&W Dome Style Camera with Infra Red

This stylish dome camera features twelve infrared LEDs that automatically operate when the ambient light level falls. The camera uses a 1/3" Samsung CCD image sensor for excellent picture quality.

Was $209 Save $20

Cat. QC-3443 $189.00

Colour also available.

Was $369 Save $30

Cat. QC-3444 $339.00

AEI 6 Sector Budget Home Alarm System

Supplied with the following:
- 2 PIRs
- 2 reed switches
- 2 alarm stickers
- 1 siren horn
- Mains plugpack
- Backup battery
- 2 x 30m rolls of alarm cable

Was $369

SAVE $50

Cat. LA-5364 $319.00

Wireless 6-Zone Home Security System

- Remote control or keypad activation
- 6 + 1 zone protection
- Limitless expandability
- Internal siren with outputs for external Siren/strobe
- Battery backup capability
- Option of hard wiring if required

Was $449

SAVE $70

Cat. LA-5460 $379.00

Melcom 8 Sector Pro Alarm Kit with LCD Keypad

The ultimate in home protection. The system includes:
- 1 x Melcom 8 sector Alarm panel
- 1 x Illuminated LCD keypad
- 3 x Micron pulse Count PIR
- 3 x N/O reed/magnet assemblies
- 2 x large alarm stickers
- 1 x siren horn
- 1 x Mains power supply
- 1 x Backup battery
- 100m roll of 6 core alarm cable
- 1 x strobe light
- 1 x siren cover
- 1 x internal siren

Was $499

SAVE $50

Cat. LA-5322 $449.00

MELCOM

Remote Control A/V Selector Scanner

- 4 Channel
- Supports composite and S-Video signals
- Full function IR remote

Was $119

SAVE $30

Cat. AC-1670 $89.00

Most Major Credit Cards Accepted

2.4GHz Wireless Audio and Video Sender with Remote Control Extender

- Powerful 10mW signal
- Composite video/audio input/output
- Includes RCA leads and mains plug packs

Was $199 Save $34

Cat. AR-1815 $165

SURVEILLANCE SALE

These special prices cannot be used in any other package deal!

B&W CMOS with Audio

Was $59.95 Save $10

Now $49.95

Cat. QC-3441

B&W CMOS Pinhole

Was $59.95 Save $10

Now $49.95

Cat. QC-3442

Micro B&W CMOS with Audio

Was $69.95 Save $14.95

Now $55.00

Cat. QC-3458

Mini B&W CCD

Was $179 Save $20

Now $159.00

Cat. QC-3473

Micro CMOS Colour

Was $139.95 Save $20

COLOUR 'Limited Quantity'

Now $119.95

Cat. QC-3459

B&W CCD with Sony Sensor/Audio

Was $169 Save $20

Now $149.00

Cat. QC-3476

Colour CCD Dome with Sony Sensor

Was $239 Save $20

COLOUR

Now $219.00

Cat. QC-3489

Colour CCD Pinhole with Sony Sensor

Was $219 Save $20

COLOUR

Now $199.00

Cat. QC-3496

B&W CCD Waterproof

Was $209 Save $30

Now $179.00

Cat. QC-3490

Colour CCD Waterproof

Was $369 Save $40

COLOUR

Now $329.00

Cat. QC-3492

4 Ch. Colour Quad Processor with RS232

COLOUR

Was $549 Save $80

Now $469.00

Cat. QC-3362

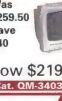
6" Dual Channel Auto Switching Security Monitor

Was $129.50 Save $30

Now $99.50

Cat. QM-3400

10" 4 Ch. Switching Monitor B&W



Was $259.50 Save $40

Now $219.50

Cat. QM-3403

960 Hr Time Lapse VCR

Was $899 Save $100

Now $799.00

Cat. QV-3053

4 Channel DVR

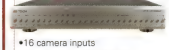
Was $3,495 Save $1,000

COLOUR

Now $2,495

Cat. QV-3052

16 Channel Colour Full Duplex Multiplexer



- 16 camera inputs
- 6 digit name assignment
- 7 different display options
- Alarm signal inputs

Was $1595

SAVE $200

Cat. QC-3366 $1395

Video Doorphone

- B&W CMOS camera with infra red
- 4" LCD monitor
- Electronic door strike control

Was $299.50

SAVE $50

Cat. QC-3412 $249.50

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Imac Blue Jiffy Box UB5

NEW PRODUCT

Utilizing the same brilliant design as the others in the series, this Jiffy box takes things one step further. It's colour is a semi transparent Imac Blue. Add a new look to your project. Size 83 x 54 x 31mm

Cat. HB-6004 $3.40

100W 3-Way Passive Crossover

- Crossover frequencies 700Hz, 3.5kHz
- 12db per octave roll off
- 100WRMS Power Handling
- 8 Ohm

Priced per unit

NEW PRODUCT

Cat. CX-2618 $29.95

Secrets of RF Circuit Design

- One of the Best RF Texts we have seen
- Technical Designs and Practical Applications
- Covers RF Theory, RX and TX design and more

Limited quantity

SAVE $10

Was $89.95

Cat. BT-1334 NOW $79.95

Bought appliances from overseas on Holidays?

Save on this Stepdown Transformer

250W 240 – 115V

- Rated at 250W 2.2A
- Dielectric Electrical Isolation

Was $129

SAVE $40

Cat. MF-1082 Now $89.00

ABS Video/Camera Case with Foam Insert

- Removable foam blocks to fit equipment
- Size 458(W) x335(H) x152(D)mm

Was $69.95

Save $15

Cat. HB-6364 Now $54.95

Laboratory Micro Burner

- 1300°C
- Piezo Ignition
- Adjustable flame

Was $49.95

SAVE $10

Cat. TS-1664 Now $39.95

Bench Stand to Suit

Was $12.95

Save $3

Cat. TS-1665 Now $9.95

Switch Pack

NEW PRODUCT

A mixed pack of assorted schadow type pushbutton as well as slide switches and assorted pushbutton caps. A must for every enthusiast.

Cat. SS-0500 $10.00

Large Waterproof Pushbutton Switch

- Durable Rubber Cover
- SADC Rating
- 22mm Cutout Diameter

Cat. SP-0732 $3.95

NEW PRODUCT

Beginners Guide to the PIC Microcontroller

- Covers Architecture and Microcode of PICs
- Includes MPLAB Development software

Limited Quantity.

Was $79.95 Save $40

Cat. BJ-6050 $39.95

Protek 506 True RMS DMM

- Dual Display
- Data Hold
- Inductance
- RS-232 Interface
- Includes holster, case & temp probe worth over $50.
- Too much to list

Was $299 Save $50

Cat. QM-1290 Now $249.00

Dwell Tacho DMM

- RPM, Dwell Angle
- 15ADC
- Continuity Buzzer

Was $78.95

Save $20

Cat. QM-1440 Now $58.95

4 in 1 Multi Function Environment Meter

- Sound Level
- Lux
- Humidity
- Temperature

Was $249

Save $40

Now $209.00

Cat. QM-1593

Bargain Bags Back Again!

NEW PRODUCT

Contains approx 2kg of assorted electronics goodies - "Junk" if you like. Ideal to fill up your junk box. Unfortunately, due to the massive weight P&P is normal rates plus $6. The picture is the contents of a bag taken off the shelf. We cannot guarantee at all that each bag will contain any of the parts pictured.

Cat. XB-9000 $17.95

Transistor Pack 2N3906 Pk50

Save $13.55 on individual parts price

NEW PRODUCT

SAVE $$$

Cat. ZT-2171 ONLY $3.95

Semiconductor Pack

NEW PRODUCT

- Over 50 assorted IC's
- About 30 assorted LED's
- About 10 assorted diodes
- About 10 assorted transistors & voltage regs.

Cat. ZP-8990 $9.95

RS-232 Auto Ranging DMM

- Capacitance
- Temperature
- Data Logging
- CD ROM Included

Was $69.95

Save $15

Cat. QM-1538 Now $54.95

Digital 1000A AC/DC Clamp Meter

- Auto Ranging
- Frequency
- Backlight
- Data Hold

Was $199 Save $40

Cat. QM-1560 Now $159.00

Non-Contact Digital Thermometer with Laser Sighting

- Measure surface temperatures without touching them
- Laser sighting for accuracy
- Range: -20 to +270°C

Was $149.50

Save $20

Cat. QM-7220 Now $129.50

New Years Saving On These Inverters!

All are 12VDC – 230VAC and Electrically Isolated

300W (900W Surge)
MI-5062 Was $159.50 Now $139.50 Save $20

600W (1500W Surge)
MI-5066 Was $299 Now $259 Save $40

800W (2000W Surge)
MI-5068 Was $389 Now $329 Save $60

1000W (2400W Surge)
MI-5070 Was $529 Now $449 Save $80

1500W (3000W Surge)
MI-5072 Was $749 Now $649 Save $100

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NEW JAYCAR KITS

Stereo Active 3 Way Crossover Kit

NEW PRODUCT

Ref: Silicon Chip 01-03
- 1 unit rack mount design
- 24dB/octave roll off
- Supplied in short form

Cat. KC-5343 $49.95

MicroMitter Stereo FM Transmitter Kit

NEW PRODUCT

Ref: Silicon Chip 12-02
- New compact design
- Frequency locked

Cat. KC-5341

$39.95

PC Powerhouse Kit

Ref: Silicon Chip 12-99
- +5, +6, +9, and 12VDC Outputs

Was $23.95

SAVE $4

Cat. KC-5281 Now $19.95

Midi Mate Interface for PC's Kit

Ref: Silicon Chip 02-01
- 2 MIDI out, 1 MIDI in, 1 MIDI through

Was $39.95

SAVE $10

Cat. KC-5306 $29.95

InfraRed Detector Kit

- Ideal for alarm, automatic lighting etc.
- Relay trigger for 1-15 seconds adjustable

Was $24.95

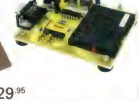
Cat. KV-3576 Now $19.95

SAVE $5

Smart Card Reader / Programmer Kit

NEW PRODUCT

Ref: Silicon Chip 01-03
- Exclusive to Jaycar Electronics
- Smart cards sold separately. Use our Cat ZZ-8800 $19.95ea.



Cat. KC-5342 $29.95

PC Auto Power-Up Kit

Ref: Electronics Australia 08-02
- Switch on/off peripherals with your PC

SAVE $5

Was $34.95

Cat. KA-1817 Now $29.95

Tiptronic Style Gear Indicator

NEW PRODUCT

Ref: Silicon Chip 01-03
- Simple 7 segment display
- Calibration for all vehicles
- Includes hall effect sensor

Cat. KC-5344 $69.95

Dr. Video – Video Stabiliser Kit

- Remove Early Versions of Macrovision
- Remove "Video Nasties"
- Cleaner sharper picture
- AC plugpack required use our MP-3006 $17.50.

Was $59.95

Cat. KC-5308 Now $39.95

SAVE $20

OUR LATEST KITS

AVR ISP Serial Programmer Kit	SC Nov 2002	Cat KC-5340	**$45.00**
5-Amp Mains Motor Speed Control Kit	SC Nov 2002	Cat KC-5339	**$55.00**
12V Inverter Kit for 40W/240V Fluoro's	SC Sept 2002	Cat KC-5338	**$99.00**
Driving Light Protector Kit	SC Sept 2002	Cat KC-5337	**$24.95**
Headphone Amplifier Kit	SC May 2002	Cat KC-5335	**$19.95**
Multi Mode Timer Kit		Cat KD-6017	**$42.95**
12V Battery Guardian Kit	SC May 2002	Cat KC-5334	**$39.95**
Itsy Bitsy USB Light Kit	SC Mar 2002	Cat KC-5328	**$12.95**
10 Channel IR Remote Control Receiver Kit	SC Feb 2002	Cat KC-5326	**$49.95**

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SERVICEMAN'S LOG

When the going gets tough

When the going gets tough, the tough get going or so the old saying goes. But in my case, when the going gets tough, I compromise, by taking on unusual service jobs – like a couple of 20-year old reel-to-reel tape recorders and a Sony set intended for South Africa.

There are times when I swear blind that I will never touch any equipment that's over 10 years old again. That's because of all the warranty implications when something else inevitably fails and because you often cannot get a critical part or it is prohibitively expensive.

But then I reach a quiet business patch and in a panic I accept not one but two 20-year old units for repair. Yes, I regret to say that muggins was guilty of this when two unrelated people brought in Sony TC-366 reel-to-reel tape recorders.

These Sony TC-366s are nicely built 3-speed machines. They have one motor, their fastest speed being 7.5ips (inches per second), and all the tape action is controlled via a large single knob. In both instances, the symptoms were no or little play torque but each fault was different.

Removing the covers involved unscrewing five Philips screws, undoing two special poles which also hold the head cover, and removing the Pause/Instant Stop switch knob. This round knob is about 1mm larger that the slot it is meant to go through when removing the tape deck escutcheon. It is screwed onto its shaft and one has to manually unscrew it in order to release the escutcheon from the machine.

Unfortunately, some 20 years later, this knob refused to unscrew, so I had to gingerly widen the slot with a round file. I really don't know why they couldn't have made it pass through when it was manufactured!

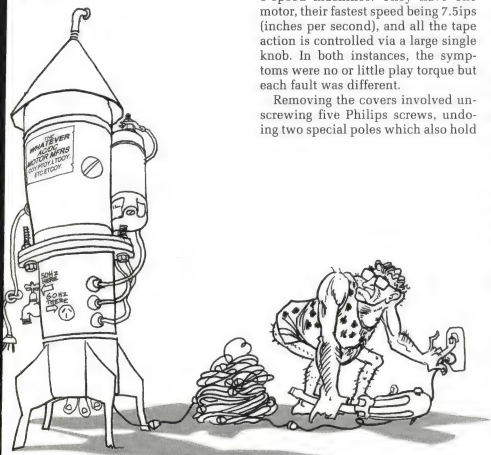
When I could finally see inside the mechanism, it was obvious that the large play idler wasn't moving to engage the motor and capstan shafts. Lubricating the bearings of the associated levers solved this problem on one of the machines.

The second was more complicated. The motor wasn't rotating at all until I gave it a little nudge. But although I could get it going, it didn't have much get up and go about it. In fact, it kept slipping, especially in fast forward, and was also getting very hot.

As a matter of interest, this particular machine had been imported from the USA and was connected to our 240V mains by a stepdown transformer. The machine was rated at 117V 60Hz and the AC motor at 100V 50/60Hz.

The 1.5µF starter capacitor (PN 117-034) looked to be the main culprit. As luck would have it, when I rummaged through an old box of capacitors I found not one but two original replacements still sealed in plastic bags. The only difference was that they had an additional 0.5µF terminal on them as well (PN 117-036).

This fixed the problem immediately but not being a rocket scientist when it comes to AC motors, I wasn't really sure whether to simply connect the 1.5µF section of the replacement capacitor or connect the 1.5µF and 0.5µF sections together to make 2µF


WHATEVER HAPPENED TO MOTHERHOOD AND APPLE PIE?
SOMETHING ABOUT IT STICKY
SOMETHING ABOUT IT STICKY
SOMETHING ABOUT IT STICKY

for 50Hz (as opposed to 1.5µF for 60Hz).

Well, I initially left it at 1.5µF and put the machine on soak test. Three hours later, I revisited it and was horrified to find that the motor was nearly too hot to touch and had stopped. The replacement capacitor had failed and I had only one left.

This time I connected the two sections in parallel, lubricated the motor and soak tested it again. Fortunately, this one held and, hopefully, will continue to do so. If not, it means ordering in a very expensive industrial one.

Anyway, I finished up with two satisfied customers, so my gamble with these 20-year old machines paid off.

An interesting Sony

An interesting TV set came in the other day. It was a 1990 Sony KV-2184SA (GP-1A). So what is interesting about that? Well, the "SA" designation in the model number (rather than AS) indicated that it was from South Africa. In addition, it had a built-in FM radio on the lefthand side of the cabinet for simulcast transmissions.

This surprised me because I thought the whole purpose of simulcast transmissions was to receive stereo and yet this was fed into the monaural TV sound system and only one small elliptical loudspeaker. So I really can't quite see the point; perhaps some expat can enlighten me, as there is no instruction book or service manual available for this model in Australia.

The set was dead, with an IC link fuse (PS801) open circuit. This led me on a merry dance as I was using my old service manual for a KV-2184AS and there was an extra transistor circuit (Q622) that wasn't marked. This supposedly monitors the current through R621 and turns off the horizontal drive from pin 27 of the jungle IC (IC301, CXA-12135) by biasing pin 22.

First, I found the D608 R2M safety zener to be short circuit, which implied the 115V rail had risen high enough to destroy it. So I replaced this, along with IC601 (STR50115, B version). I then found that R621 (1Ω) had gone high, as well as R622 (470kΩ).

I was getting closer but the set gave a high-pitched squeal when I switched it on and the 115V rail was at 87V. Yet when connected via a 100W globe, with a clip lead between base and emitter of the horizontal output transistor, the voltage was spot on at 115V and there was no squealing.

When I re-enabled the horizontal output stage, I could get sound and a white raster. And when I subsequently replaced R851 1.2Ω (200V supply to the CRT), I could get a coloured picture, albeit small and distorted due to the low HT.

From this, I deduced that the horizontal output stage might possibly be drawing too much current. But it wasn't and it took a very long time to work out that R609, a 33Ω 3W resistor, was open circuit in the power supply and that this was part of a feedback circuit to pin 2 of IC601.

By now, I had a good picture and sound when I connected a video recorder to the AV inputs. However, that wasn't the case off air.

The reason for that wasn't hard to figure out. South Africa uses the CCIR system with a 6MHz sound IF and with no Band I VHF (V-L). This meant removing the IF module IF201 (IFB-389SA) and replacing the three 6MHz ceramic filters with 5.5MHz units (CF01 for D5.5E, CF02 5FE5.5MB and CF03 T5.5B). The set now gave good sound and colour for all stations except for the ABC (Ch2, Band I).

Now all that was left to be done was to fit the extra band switching transistor (Q151, DTA114ES) – along with 6.8V zener D152 and C150 (1µF 25V) – and link it to pin 7 of microprocessor IC002 via a 2.2kΩ resistor (R098). I did all this but it still didn't work. The

Items Covered This Month

- Sony TC-366 reel-to-reel tape recorders.
- Sony KV-2184SA (GP-1A) TV set.
- AWA 65850 S/T TV set.
- Grundig ST70-755 TOP/LOG TV set (CUC 6360 chassis).
- AWA C5105 TV set.

transistor would still only scan high-band VHF (ie, no Band I) and UHF.

Initially, I thought this was due to the microprocessor being a PCA84-C640P/037 instead of PCA84C640P/016 as in the circuit diagram. However, this was just a red herring as I discovered that the Australian module also used the same "037" suffix and worked OK.

What I did discover was an extra diode (D005) fitted in the South African model that connected pin 22 to the vertical pulse going to Q005 from the vertical output stage. Removing this diode breaks the TV scan mode into VL, VH and U and the set could now be tuned like an Australian TV receiver.

Obviously, the easiest way to solve the above problem would have been to fit an Australian tuner and an the IF module as well (as they would be better matched). However, I hadn't scrapped any of these sets lately, so I couldn't scrounge the necessary parts and fitting new units would not have been cost-effective.

Finally, to select the simulcast FM radio, it is necessary to rotate the system switch inside the front control panel and then tune the knob on the side. The tuner is connected via CN302 and CN201 to the de-emphasis pin (pin 10) on the IF module and pin 7 of analog switch IC702.

AWA TV set

AWA is now used as a brand name on a series of TV sets imported from China. These sets are very similar to those of Teac, Akai and Masuda, and are probably produced by the same ONWA factory.

In fact, the 1993 66cm AWA 6850ST on my bench could easily have been mistaken for a Teac CT-M711 or a Masuda 28AV. And it was completely dead.

After removing what seemed like an unnecessary quantity of screws, the set was seen to consist of a motherboard, a Teletext board, a stereo decoder and a power supply. And a quick examination soon revealed that two capacitors in the power supply had spilled their guts.

I replaced the two culprits – namely C910 47µF 25V and C908 10µF 50V – before replacing the parts they had destroyed: Q909 (2SD1403), R944 (2.2Ω, 5W), C925 (1000µF, 25V), R916 (0.68Ω, 1W) and C925 (22µF, 160V). Judging by the soldering, I wasn't alone in going down this path. I also checked the HT voltage and set it to 143V at TP B+.

Intermittent flicker

The next problem was the picture which was intermittently flickering horizontally with colour problems. Sometimes the picture would tear and sometimes it would shift horizontally. It's not only a horrible fault to describe but was equally hard to diagnose and fix. And it was somehow temperature related, the set getting better when hot.

By trial and error, I discovered that the fault seemed to be located around IC102 (TDA8305A). This is predominantly an IF detector processor but also a jungle IC and is located underneath the stereo decoder board in a soldered-in metal cage. There was a lot of black silicone rubber all over this set which, like the brown glue before it, tends to conduct after many years.

Well, I had to start somewhere so I scraped off the black silicone rubber and replaced the IC. This didn't work, so I started replacing the capacitors. Fortunately, I struck gold with C127 (3.3µF), which is a decoupling capacitor for the AGC detector and sync demodulator.

At this time, I didn't have a remote control but fortunately I had a Remote Master RM0900 Universal remote control and tuned that into this set's command set. This was a good idea, as I found then that the remote control power on/standby function wasn't switching off.

This set used a relay for switching the 143V on and off to the rest of the set, so it was just a matter of tracing it back to the microprocessor. However,

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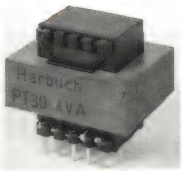

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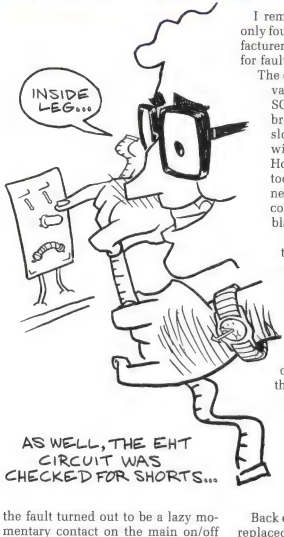


the fault turned out to be a lazy momentary contact on the main on/off switch (S512) that was sticking in the on position. A little lubrication soon fixed that and the set was back in operation.

Grundig day

I don't see many Grundig TV sets these days, probably due to the dealer network set up by Grundig in recent years. I normally try to avoid house calls but when Fred Schmidt called and gave me his address as being only a block away, I bent the rules and arranged to "have a look" at his 10-year old Grundig ST70-755 TOP/LOG (CUC 6360 chassis). The fault complained of was intermittent no picture and it was the "intermittent" bit that worried me.

When I arrived, the set gave no picture but a green raster with retrace lines. After it had been on for sometime, the picture flashed on.

I removed the back – there were only four screws to undo (other manufacturers please note) – and checked for faulty joints or anything obvious. The only thing I learnt was that by varying the CRT screen control SG/VG2 clockwise to give a very bright green raster and then slowly reversing it anticlockwise, the picture would return. However, it was too bright and too green and turning the brightness control down on the remote control still couldn't make the blacks black.

Basically, if the screen control is turned too far anticlockwise, the picture loses definition and gives poor colour contrast.

This looked to me like the RGB video output stage was producing signals that were outside the optimal characteristic curve sections of the CRT guns. I told Fred that it had to go to the workshop and though it was a fine TV set, perhaps he ought to think about updating it considering its age. However, being rather short of cash, he decided to have the set fixed rather than dumped.

Back on the workshop bench, I first replaced the RGB video output IC (IC790, TEA5101A/D), which is a very complex FET amplifier. Initially, I fitted a generic IC from my local supplier but later, when I became more desperate, and at Grundig's suggestion, I ordered and fitted a genuine replacement but it made no difference either way.

This type of circuit is used in a lot of European-designed sets like Philips and the fault can quite often be caused by a low-emission tube. To prove this one way or another, I decided to test the Philips A66 EAK71X01 picture tube thoroughly. First, I connected my CRT analyser directly to the tube and, at 6.3V RMS, I measured an even 0.62mA emission from each gun, which is reasonably good.

Next, I measured the voltage across the CRT filaments with my RMS voltmeter and that too was spot on at 6.3V. Finally, I connected an external power supply to the heaters and wound it up to 8V to see if it made any difference but it didn't.

I now concentrated on the diodes and electrolytic capacitors on the CRT module (29305-022.48). Note that this differs from the one in the service manual (29305-022.44) – it has four more diodes fitted, as well as other modifications.

I tried replacing all the 1N4148 diodes with higher-rated BAV21 (used mostly as clamps) but that didn't help. I also measured all the voltages around the CRT socket but of course, the voltage for each colour was not consistent and besides, the service manual does not give voltages.

The thing I did notice was that the voltage drive for each colour from the colour decoder module was 4V for red and blue and 5V for green. I also measured the beam limiting SB voltage from the horizontal output transformer (A) on pin 1 of the module to be 16V and the SW voltage on the CRT RGB pin 1 plug to be 0.63V in the fault condition. I should also add that it was not possible to set up the screen control according to the alignment instructions, as the picture would be far too bright (in AV mode, there should be 172.5V on each cathode). The EHT was spot on.

Colour module

All this was very time consuming and all I had really achieved was to confirm that the CRT and socket were probably OK. So now I shifted my attention to the colour module – 29504-105.67 – which also differs from the 29504-105.56 module in the service manual.

The other drama with this double-sided module concerned the access to its surface-mount components. About all I could measure were the voltage supplies (12V, 8V) and the inputs and outputs. Fortunately, the service manual gave a pretty good explanation of the circuit.

The circuits I was interested in were mostly in IC5040 (TDA8376) and the 10 surface-mount transistors after it. I pulled the module out and using an ohmmeter, checked all the transistors to be OK. I then replaced all the electros and measured all the diodes. An exchange module (if available) would cost $227.25 trade and the TDA8376 $119.70 plus freight charges of $11.

I gambled on the latter and ordered it. A few days later, after replacing this 52-pin high-density IC, I discovered I had lost and blown all my money!

So far I wasn't doing very well. If only I had had another set to compare it with. As I had the necessary ICs in stock, I replaced all the other ICs on the Chroma Module but even that was a waste of time.

Finally, I decided to replace the surface mounted transistors, starting with CT5127 (Red), CT5128 (Blue) and CT5129 (Green) – all BC858s. Naturally, with my luck, these are no longer available, so I fitted BC858Cs. This fixed one problem – the green caste was gone and the grey scale was correct even if it was too bright.

I surfed the net and found one German site for TV and Video Service Repair Tips that had to be translated, suggesting I replace CT5066, another BC858. This I did and I noticed a small improvement. Thus encouraged, I moved along and replaced CT5060 as well. This finally produced an acceptable picture after realignment. These transistors are part of the beam limiting current circuit to pin 22 of IC5040 (3-4V).

I couldn't fault any of the PNP transistors I replaced but because of their size and position, it was almost impossible to hook up complicated test gear to test them. I have even had cases where the glue used to cement these components onto the board affected their characteristics.

Anyway, the picture was now quite acceptable but will Fred go ahead with my quote? How could I possibly guess at the likely cost beforehand?

And to finish off, here is another reader contribution. It is from A. B. of Glen Waverley, Victoria. He has titled it:

The perils of modern test gear

Mr Smith staggered up the path clutching an AWA C5105 TV set, moaning "I couldn't find the place". I resisted the temptation to ask if he had seen the sign out the front but in this game you soon learn that the customer has a good reason for whatever they say.

"Its dead, just stopped – is it the picture tube?" he puffed on. After reassuring him it was unlikely, I booked it in and shoved it onto the "look at" pile.

I got to it a few days later. It was a 51cm AWA set of Chinese manufacture and only about 18 months old. The first thing you do in these sets is go straight for the power supply, in this case the electrolytic capacitors in the primary circuit (C614 and C615). Both measured faulty on the ESR meter and were promptly replaced. As well, the EHT circuit was checked for shorts and a DC resistance measurement to chassis showed no obvious faults.

The set was then powered up and I fully expected it to burst into life. Alas, it was not to be – the red standby LED was on but no amount of prodding at the usual user controls made any difference.

At this point, you start to wonder if the remote control is needed to start the set – most modern TV sets are switched on by firing a start-up pulse from the remote using the on/off button or a channel button. I worked on this assumption and turned the chassis upside down on the workbench to access the underside of the board.

It was soon established that the HT rail was at 110V – a figure I assumed to be OK on a set this size. After diligently studying the circuit, a 5V regulator and an 8V regulator were also found to be functioning. As well, there was HT on the collector of the horizontal output transistor and about 85V on the collector of the driver transistor.

However, a quick check with the CRO revealed that there was no drive waveform to the base of the driver transistor. Unfortunately, the relevant track soon disappeared into a mess of similar tracks wandering all over the board.

At this point, it was decided to obtain a circuit diagram. Unfortunately, when this turned up, it proved to be a 15th generation copy (or thereabouts), plus a booklet full of useless (in a practical sense) information on how to do alignments, etc.

The circuit was of limited help as all the figures were unreadable. However, I did manage to locate the jungle IC and I checked that this had supply volts. I also discovered that there was no horizontal drive waveform on the relevant output pin.

So what was going on? All the routine tests had been done to no avail. After staring at the board, I decided to measure all the high-wattage low-value resistors. All checked OK (or as near as could be judged given the useless circuit diagram) with the exception of R320, the dropping resistor to the horizontal driver circuit - it was reading about 6MΩ! However, the HT on the transistor measured OK at 85V!

Suddenly the penny dropped, and I mentally kicked myself around the workshop. I pulled the resistor out and replaced it with a 2.7kΩ 5W unit, switched on the power and the set came to life.

What happened?

So what had happened – easy, and if I had remembered basic theory I would have found it a lot quicker. What happened was this – at switch on, the start-up pulse gives enough energy to kick the set into life and all is well. In this case, because the set wasn't running, my high impedance digital multimeter was indeed reading a nearly correct voltage across the driver transistor because the thing was still stuck in standby mode, the transistor not drawing any current.

By contrast, an old, cheap analog meter with its higher loading would have shown a lower voltage at this point and the true fault would have been revealed at once!

Ah well, that's the problem with getting older – what was once routine is now new if you haven't seen it for awhile. SC

This stereo 3-way active crossover is for those enthusiasts who want the very best from their 3-way loudspeaker systems. It avoids the disadvantages of passive crossover networks and allows the power levels to the speakers to be optimised.

What is an active crossover and why would you want one?

Most hifi enthusiasts are aware that 2-way and 3-way loudspeaker systems contain passive networks to split up the audio spectrum into two frequency bands in the case of 2-way systems and three bands in the case of 3-way systems.

Passive crossover networks use inductors, capacitors and resistors to split the audio into the various bands and set the signal levels to the various speaker drivers.

For example, the woofer is often less sensitive than the midrange driver and tweeter and so the signals to the latter drivers have to be reduced so that the overall output from the three drivers is equal.

In the higher performance speakers, the crossover networks are often very complex and they can be very difficult to design and optimise. And because they usually do attenuate the midrange and high signals, that means they do waste amplifier power.

They also interpose a complex network between the speakers and the amplifier which means a loss of damping factor, particularly for the lower frequencies where it is most needed, if you are to achieve tight, clean bass and midrange reproduction.

OK, so that's the passive approach. It involves just one

Features

- 1-unit rack case
- Single PC board
- 15V+15V 20VA toroidal transformer
- Stereo module
- Buffered input and output stages
- Individually variable outputs (trimpots)
- On-board power supply
- On-board RCA connectors
- Made from standard components

An active 3-way crossover for loudspeaker systems

MIDRANGE
BANDPASS

Design by Mick Gergos

stereo amplifier to drive the two speaker boxes in a stereo system.

In an "active" system, we eliminate the passive crossover networks and electronically split each of left and right channel signals into three frequency bands: low, midrange and high. This is the job of the "active crossover".

Its output signals are fed to six (yep, six) separate amplifiers to drive the woofer, midrange and tweeter units in each loudspeaker enclosure. The overall system layout is shown in the block diagram of Fig.1.

So you end up with a lot more amplifiers than in a conventional system but it gives you a lot more flexibility. And ultimately, you can end up with a system with higher performance, including much higher power levels.

This shot inside the box reveals the simplicity of construction. Everything except the transformer is on one PC board!

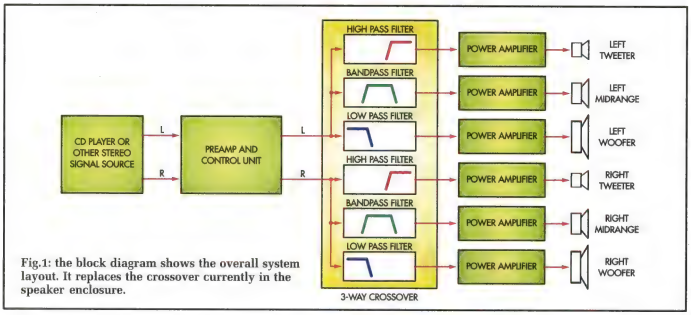


Fig.1: the block diagram shows the overall system layout. It replaces the crossover currently in the speaker enclosure.

The active crossover approach also means you can mix 4Ω and 8Ω drivers in the same system and match the levels easily, without power wastage.

Active crossover

The Active Crossover presented here is housed in a 1-unit high rack case with just the power switch on the front panel.

There are no user controls for the crossover; no switches to alter the crossover frequencies nor external level controls for the output signals. To alter the drive to the loudspeakers, you will need to adjust the volume controls of the driver amplifiers.

On the rear panel there are four pairs of RCA sockets, one pair for the stereo input signals while the other three are for the stereo low (woofer), midrange and high (tweeter) signals.

Also on the rear panel is the IEC mains power socket and a fuseholder for the primary circuit of the power transformer.

Inside the case, all the circuitry is on a PC board measuring 219 x 99mm and this includes the dual RCA input and output sockets. The only external wiring to the board are the secondary connections to the toroidal power transformer.

Circuit description

Now let's have a look at the circuit of Fig.2. Since both channels are identical, this shows only the left channel. While the power supply is also on the PC board, it is shown in Fig.3.

In total, the left channel uses 12 op amps, in three TL074 quad FET-input op amp packages.

Four op amps, IC1a, IC1b, IC5a & IC5b, act as input or output buffers while the remaining eight op amps are Linkwitz-Riley active filter stages with 12dB/octave filter slopes.

In each case, two 12dB/octave filters are cascaded to give an overall filter slope of 24dB/octave. This is far steeper than is normally used in passive crossover networks.

The voltage gain of all these filter stages in the passband is unity.

Low pass, high pass

Before we go any further we should explain some terms which often confuse beginners: low pass, high pass and bandpass.

A low pass filter is one that allows low frequencies to pass through and it blocks the higher frequencies. Hence, a circuit to drive a subwoofer would be called a low pass filter since it only delivers frequencies below 200Hz or thereabouts.

Similarly, a high pass filter is one that allows high frequencies to pass through and it blocks low frequencies. Hence, the part of a crossover network which feeds a tweeter is said to be a high pass filter, even though it may consist of only one capacitor.

If we cascade (ie, connect in series) a high pass filter with a low pass filter, the combination will pass a band

Specifications

Voltage gain:	Unity
Frequency response	Within ±1dB from 10Hz to 20kHz (see Fig.5)
Filter attenuation slope	24dB/octave
Total harmonic distortion	Typically .003% at 1V RMS
Signal to noise ratio	-94dB unweighted (22Hz to 22kHz) with respect to 1V RMS
Separation between channels	Typically better than -100dB from 10Hz to 20kHz
Input impedance	47kΩ
Output impedance	less than 200Ω

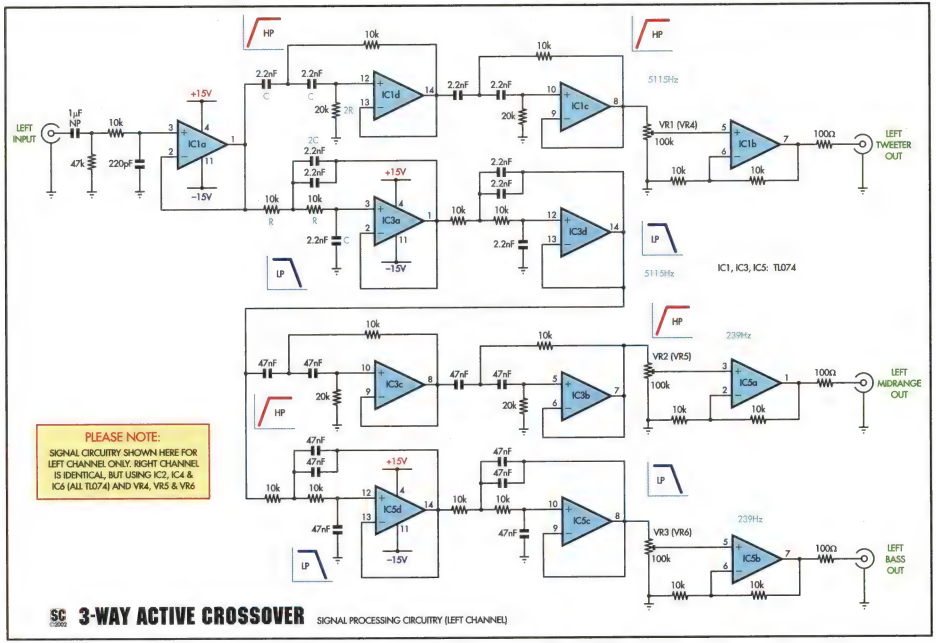


Fig.2: just 12 op amps and a few other components make up each channel of the active crossover. The six outputs (three only shown here; three more in the right channel) each drive separate power amplifiers for the tweeter, midrange and bass drivers in your loudspeakers.

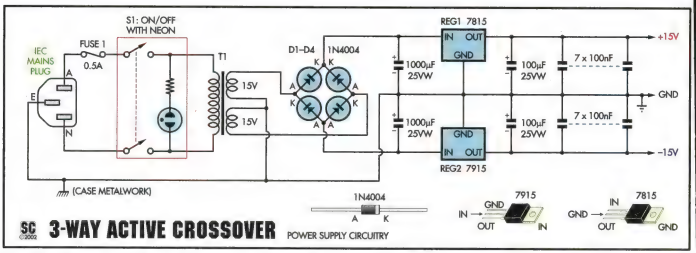


Fig.3: the power supply is entirely conventional, using positive and negative 15V regulators to give ±15V rails. Everything from the bridge on is mounted on the PC board. The seven 100nF capacitors are bypasses distributed around the PC board.

of frequencies and we then refer to it as a bandpass filter. We use a bandpass filter for the midrange output in this active crossover circuit.

The other points you need to know about high and low pass filters are the so-called cut-off frequency and the filter slope.

The filters used in this circuit have an attenuation of 12dB/octave; this is the filter slope and it applies for frequencies after the cut-off frequency. The cut-off frequency is where the signal output is -3dB down on the normal level.

For example, in a low pass filter we might have a cut-off frequency of 1kHz (ie, -3dB point) and from there on the filter slope could be 12dB/octave. In theory, this means that the response at 2kHz (ie, one octave above 1kHz) will be -15dB although in practice it might not be quite that good.

The filters used in our circuit are of the Linkwitz-Riley configuration and we use eight of these filters, four high pass and four low pass, in each channel. Each filter consists of an op amp connected as a voltage follower, preceded by two RC networks.

As already noted, for each high pass and low pass filter we are using two 12dB/octave filters cascaded, to make the total roll off 24dB/octave (4th order) per filter stage.

The basic filter configurations are shown in Fig.4, together with the formula for calculating the crossover frequency. In this particular case, the crossover frequency is at the -6dB point and the reason for this is that we are cascading two filters for each section (2 x 3dB = 6dB).

Note that the capacitors in the low pass filter are shown with values of C and 2C while in the high filter we have resistors with values of R and 2R.

In the main circuit of Fig.2 you will note two capacitors of equal values have been used for the 2C component, as it is difficult to obtain capacitor values exactly double that of another. On the other hand, resistors are much easier and so we have values of 10kΩ for R and 20kΩ for 2R.

Now after that little diversion, let's refer back to the circuit of Fig.2.

The input to the left channel is fed via an RC filter, to roll off frequencies above 100kHz, and then to op amp IC1a which is connected as a unity gain buffer (or voltage follower).

It drives two high pass filter stages associated with IC1d & IC1c, and two low pass filters associated with IC3a & IC3d. Both these low pass and high pass filters have cutoff frequencies set to 5.1kHz.

The output of the second high pass filter, IC1c, is fed to the level setting trimpot VR1 and then to op amp IC1b which is connected as a non-inverting amplifier with a gain of two. It drives the left treble output (tweeter). Hence the tweeter only gets frequencies above 5kHz.

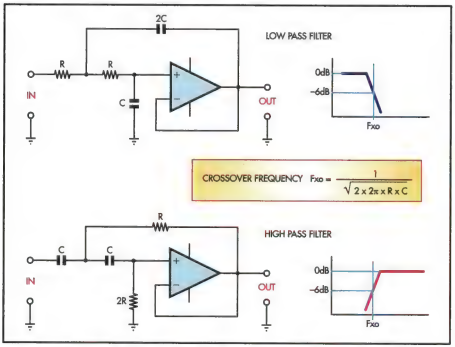


Fig.4: the basic arrangements for the low pass and high pass filters.

Midrange band-pass

The output of low pass filter IC3d

feeds high pass filters based on IC3c & IC3b, both with cut-off frequencies of 239Hz. The output of high pass filter, IC3b, is fed to trimpot VR2 and then to op amp IC5a which has a gain of two.

This drives the left midrange output which gets the band of frequencies between 239Hz and 5.1kHz.

As well as driving high pass filters IC3c & IC3b, op amp IC3d also drives the cascaded low pass filters based on IC5d & IC5c, again with a cut-off frequency of 239Hz. IC5c drives trimpot VR3 and then op amp IC5b which has a gain of two. It drives the left bass output which only gets signals below 239Hz.

All the outputs from each stage are in phase at the crossover points. Voltage gain at the crossover frequency for each section is -6dB (ie, half the reference level).

Thus when the response curves of all three sections are added together, the result is an extremely flat frequency response with an overall gain of unity.

Just how well this works is shown in the response curves of Fig.5. We've plotted the three filter responses and then the resultant curve is plotted along the top. The adder circuit we used to do this is shown (for interest only) at the end of this article in Fig.8.

Parts List – 3-Way Active Crossover

1 1RU rack-mounting case, Altronics H-5011 or equivalent
1 PC board, code 01101031, 219 x 99mm
1 IEC power socket
1 chassis-mount safety fuseholder (3AG or M205 type)
1 0.5A fuse (3AG or M205 type to suit fuseholder)
1 DPST rocker switch with inbuilt neon (S1)
1 20VA toroidal transformer with 2 15V secondaries
1 3-way insulated terminal block
4 dual gold-plated RCA PC-mounting sockets, Altronics P-0212 or equivalent
6 multi-turn 100kΩ trimpots (VR1-VR6), Altronics R-2382A or equivalent

Semiconductors
6 TL074 quad FET-input op amps (IC-IC6)
1 7815 positive 3-terminal regulator
1 7915 negative 3-terminal regulator
4 1N4004 silicon diodes (D1-D4)

Capacitors
2 1000µF 25V PC electrolytic
2 100µF 25V PC electrolytic
2 1µF 50V bipolar electrolytic
14 100nF (0.1µF) multi-layer ceramic (code 100n or 104)
20 47nF (.047µF) metallised polyester (code 47n or 473)
20 2.2nF (.0022µF) metallised polyester (code 2n2 or 222)
2 220pF ceramic

Resistors (1% metal film)
2 47kΩ (yellow violet orange brown or yellow violet black red brown)
8 20kΩ (red black orange brown or red black black red brown)
38 10kΩ (brown black orange brown or brown black black red brown)
4 100Ω (brown black brown brown or brown black black black brown)

Power supply

The power supply circuit is shown in Fig.3. It uses a 20VA toroidal power transformer with two 15V secondaries driving a bridge rectifier (diodes D1 - D4) and two 1000µF 25V capacitors to derive unregulated DC supplies of around ±22V DC. These are fed to 3-terminal regulators REG1 and REG2 to produce supplies of ±15V DC. These are each bypassed by a 100µF 25V capacitor and seven 100nF multi-layer ceramic capacitors distributed around the PC board.

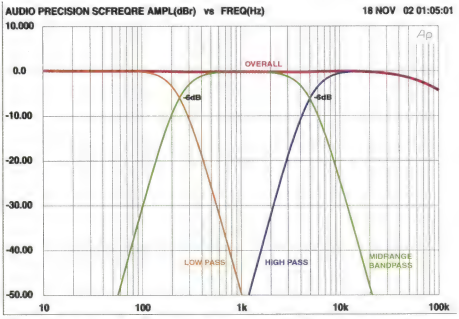


Fig.5: this graph shows the three filter response curves which were plotted separately. The overall response curve at top (red) was plotted using the mixer circuit in Fig.8. The overall response curve is extremely smooth.

Construction

As already noted, all the circuitry is on a single PC board measuring 219 x 99mm, so construction is very straightforward.

The only complication will occur if you you wish to set your own crossover frequencies. If so, you will need to select values from Table 1.

For example, if you decide you want a tweeter crossover frequency of around 3kHz, go to Table 1, run your finger down the righthand column until you get to 3100 and the R and C values are in columns 1 & 2.

In practice, the 2.2nF capacitors in the high- pass and lowpass filters associated with IC1 and IC3 now have to be changed to 3.3nF, while the 10kΩ

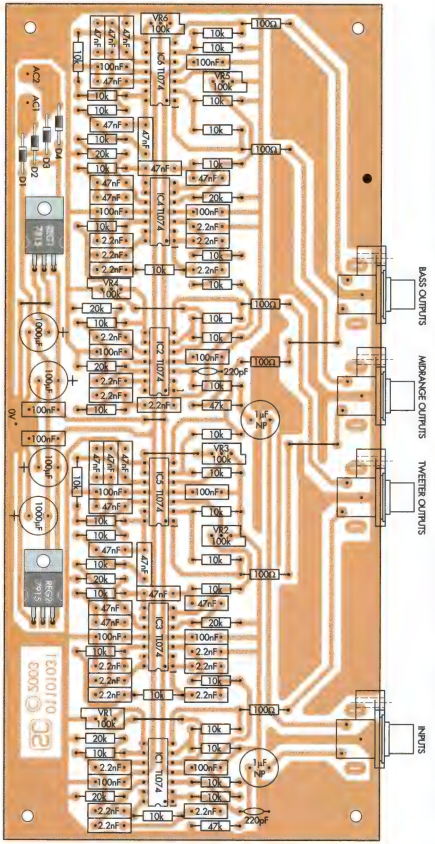


Fig.6: the component overlay, as viewed from above the PC board. Note the polarity of electrolytic capacitors and ICs when soldering them in!

resistors increase to 11kΩ and the 20kΩ values go to 22kΩ.

Note that it is essential that both the high pass filters (ICd & IC1c) for the tweeter and the low pass filters (IC3a & IC3d) for the midrange must have exactly the same cut-off frequencies otherwise you will not get an overall flat frequency response.

Similarly, if you want to change the bass cut-off frequency to around 350Hz (say), run down the righthand column of Table 1 to 347Hz. The R values then become 11kΩ and 22kΩ while the C values become 27nF.

Alternatively, if you want to do the calculations yourself, visit www.sherlab.com/filter/filter.htm for a filter calculator.

Lots more information regarding Linkwitz-Riley crossovers can be found at www.rane.com/note107.

Here they discuss lobing errors, driver alignment & phase correction, phase shift vs frequency etc.

Having decided on your crossover frequencies, you can start assembly of the PC board by closely checking it for shorts between tracks, open circuits etc, against the pattern opposite.

Then install all the resistors, followed by the capacitors and multiturn trimpots. Make sure that the electrolytic capacitors are installed the right way around. The bipolar electrolytics are not polarised and can go in either way.

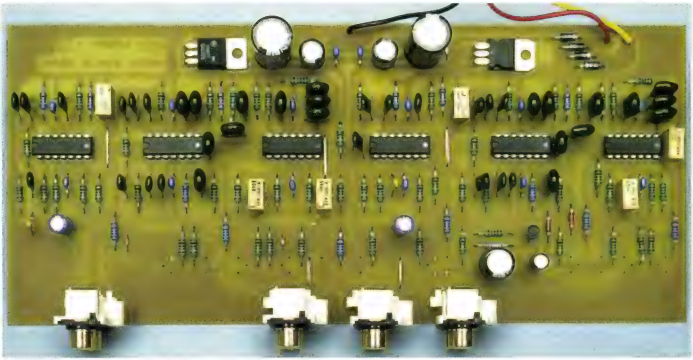
Ideally, 1% capacitors should be used in all of the filter circuitry. As an alternative, purchase a bag of 100 capacitors of the value you require and pick the 20 that are the closest in value to each other, using a capacitance meter or DMM with capacitance ranges.

Next, install the two regulators which are laid flat on the PC board. Be careful not to swap them over otherwise the circuit definitely won't work and you may have to replace quite a few damaged semiconductors. Finally, you can install the op amps and the RCA sockets.

You will then need to wire up the power transformer, using the diagram of Fig.7. Temporarily install the PC board into the chassis and you are ready for some voltage checks.

Voltage check

Apply power and check the regulated supply rails with your digital



This photo of an early prototype PC board shows the general layout of components. It should be noted that there have been substantial changes since this photo was taken, particularly along the bottom (rear) of the board. The component overlay (Fig.6) shows the final version.

multimeter. They should be close to ±15V DC.

Then check that +15V is present at pin 4 of each TL074 and that -15V is present at pin 11 of each IC. Lightly touch each IC to ensure that none of them are getting hot – they should all be cool.

The next step is to align the whole circuit using the trimpots. This is a simple matter of setting up each output for unity gain in its passband. This can be done at three frequencies, say 100Hz for the bass, 1kHz for the midrange and 12kHz for the treble.

You will need an audio oscillator and a digital multimeter with an AC frequency response to 20kHz or better. Connect your audio oscillator to the input RCA connector in one channel. Set the frequency to 100Hz, 1kHz or 12kHz, depending on which section you wish to align. Set the level of the oscillator to 1V RMS.

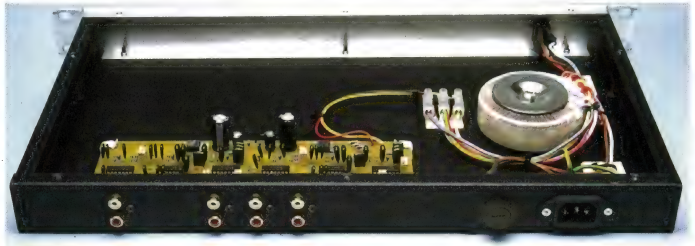
Then measure the signal level at the output of the stage that you are adjusting. For the treble output, use 10kHz and adjust trimpot VR1 (left channel) or VR4 (right channel) to obtain 1V RMS at the output socket.

Similarly, for the midrange, use 1kHz and adjust VR2 (left channel) or VR5 (right channel) to obtain 1V RMS at the output sockets.

Finally, for the bass, use 100Hz and adjust VR3 (left channel) or VR6 (right channel) to obtain 1V RMS at the output. That done, it is now a matter of finally completing the wiring inside the case and checking it before connecting the unit to your amplifiers.

Your amplifiers

We mentioned before that six amplifiers are required; one for each of the bass, midrange and treble speakers, times two (for stereo). But what amplifiers should you use?



The completed project showing the rear panel arrangement, power supply wiring and PC board placement. Use this in conjunction with Fig.7 (opposite) during final assembly.

Fig.7: follow this wiring diagram and you should have no problems with final assembly. Be especially careful with the mains wiring – note the heatshrink covering all the "bitey" bits!

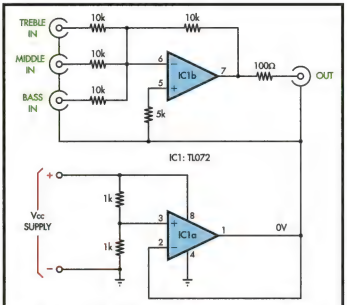


Fig.8: here is the adder circuit we used to produce the diagram shown in Fig.5. You don't have to make one of these unless you are interested in measuring your own circuit.

Typically, the woofer amplifier needs to be about double the power of the midrange and tweeter amplifiers, to take into account the lower sensitivity of the woofers.

So if you have been running a 100W per channel stereo amplifier into your 3-way speaker system, you will still need two 100W amplifiers for the woofers (eg, your exisiting amplifier!) but you can get away with two 50W amplifiers for each of the midrange and tweeters (ie, four total).

You may be able to put back into service an amplifier that you pensioned off as "underpowered".

Or, if you want to go the whole hog and build new amplifiers to go with your new active crossover, you could do a lot worse than the new SC480 amplifier module featured in this issue for the midrange and treble.

The Ultra LD (Nov, Dec 2001, Jan 2002) or even the Plastic Power module (April 1996) would make a superb bass amplifier.

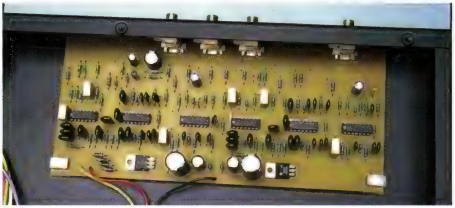
Connection

It is simply a matter of connecting the stereo outputs from the 3-Way Active Crossover to the appropriate bass, midrange and treble stereo amplifier inputs, then connecting the amplifiers' outputs direct to the appropriate drivers in each of the speaker enclosures.

Needless to say, the existing crossover network in the speaker enclosures is disconnected completely – and you will need to put an extra two sets of terminals on the back of your enclosures with each of the three connected directly to a driver (and appropriately labelled).

The tone controls should ideally be flat on all amplifiers (although that can be a matter of individual taste – but the treble control won't do much on the bass amplifier nor the bass control on the treble amplifier!).

Volume controls can be individually adjusted to get the best balance between the bass, midrange and treble speakers. SC



There are no screws holding the PC board in place. Instead it sits on self-adhesive holders (as used in many computers) and the RCA sockets on the back panel are themselves held in by screws.

Table 1: Values for R & C

R (kΩ)	C (nF)	2R (kΩ)	Crossover Frequency (Hz)
15	47	30	160
15	39	30	192
12	47	24	200
11	47	22	218
15	33	30	227
10	47	20	239
12	39	24	240
11	39	22	262
15	27	30	278
12	33	24	284
10	39	20	289
11	33	22	310
7.5	47	15	319
15	22	30	341
10	33	20	341
12	27	24	347
11	27	22	379
7.5	39	15	385
10	27	20	417
12	22	24	426
7.5	33	15	455
11	22	22	465
10	22	20	512
7.5	27	15	556
7.5	22	15	682
15	4.7	30	1596
15	3.9	30	1924
12	4.7	24	1995
11	4.7	22	2177
15	3.3	30	2274
10	4.7	20	2394
12	3.9	24	2405
11	3.9	22	2623
15	2.7	30	2779
12	3.3	24	2842
10	3.9	20	2886
11	3.3	22	3100
7.5	4.7	15	3193
15	2.2	30	3410
10	3.3	20	3410
12	2.7	24	3473
11	2.7	22	3789
7.5	3.9	15	3848
10	2.7	20	4168
12	2.2	24	4263
7.5	3.3	15	4547
11	2.2	22	4650
10	2.2	20	5115
7.5	2.7	15	5558
7.5	2.2	15	6821

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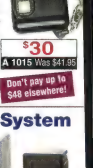

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CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.

Motor speed control with protection

This DC motor speed controller provides compensation for the voltage drop in the armature circuit. Voltage drop in the armature circuit is mostly responsible for the poor low speed running characteristic of small motors. This characteristic is most noticeable at start up and when running at low speed driving a varying load. Small motors can have an armature resistance of less than one 1Ω to several tens of Ohms.

From DC electric motor theory:

$\mathbf{V_m = V_b + I_aR_a}$

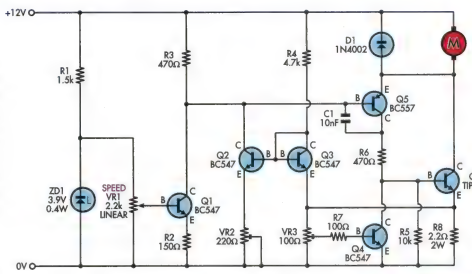
where V_m is the applied voltage; V_b is the back-EMF generated by the armature, proportional to the speed; I_a is the current in the armature circuit; and R_a is the armature resistance.

When a motor is running without a load, it will draw only a small current and so I_aR_a will be small. Conversely, its speed will be high and so V_b will be high as well. When the motor is loaded, it draws more current and so I_aR_a will be increased. The speed will therefore reduce and so will V_b.

For a given motor speed, the applied motor voltage must be increased to compensate for the increase in I_aR_a. This circuit can perform this task. It works as follows. The speed setting control VR1 adjusts the base voltage of Q1 to set the current flow in resistors R2 & R3. The voltage across R3 is applied to the base of the compound transistor comprising Q5 & Q6 and this drives the motor.

Q2, Q3 and VR2 provide compensation for the armature voltage I_aR_a. The motor current flows through Q6 and its emitter resistor R8 and the resulting voltage is applied to the emitter of Q3 to be reflected at the emitter of Q2 and applied to trimpot VR2. Varying the resistance of VR2 thus changes the voltage across R8.

This means that the voltage across R3 has two components, the speed setting from VR1 and the speed compensation from VR2.



VR2 must be adjusted to provide the correct amount of compensation otherwise the motor will surge or stall whenever a load is applied.

VR3 sets the maximum current, to protect the speed control circuit or the motor itself from excessive load.

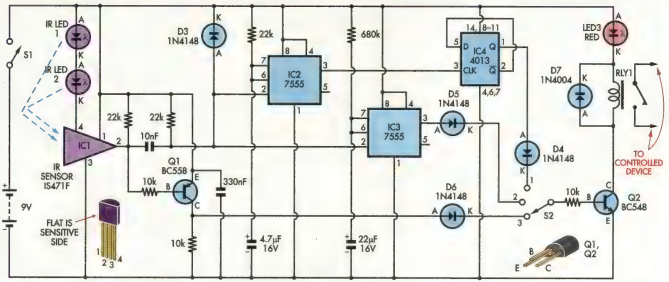
Before adjusting VR2, make sure the wiper of VR3 is at 0V. Then adjust VR1 to run the motor slowly, say about 200 RPM. Load the motor by pinching the motor shaft with your fingers. Now adjust VR2 so that the motor runs smoothly without stalling or surging. Depending on the motor, speeds of 60 RPM under varying load should be easily achievable.

C1 gives the circuit stability. However, if your motor and cable capacitance is large, surging (instability) may occur. C1 can be increased to compensate. Q6 must have a heatsink.

For motors with less than 6Ω armature resistance, change R8 to 1Ω. If the armature resistance is greater than 20Ω, change R8 to 4.7Ω. A value of 2.2Ω suits motors in between.

VR3 is adjusted to limit the current as desired.

Duncan Graham, Hamilton, NZ.



The circuit uses an IR sensor to pick up the reflected light from two IR LEDs, plus two CMOS 7555 ICs (IC2 & IC3) to debounce the incoming signal and provide timing. Switch S2 is used to select between toggle on/off operation, timed operation & "press switch" operation (see text).

Magic wand for 3-way control

This was devised to enable handicapped children who lack manual dexterity to operate electrical toys.

No doubt it could have many other applications.

A wave of the hand or a "magic wand" over the box can operate the relay in three ways:

(1) as a toggler – one wave on, next wave off;

(2) as a timer – one wave turns it on for a set time;

(3) as a press switch – hold the wave over the sensor and the relay stays closed.

The circuit depends on infrared sensor IC1 which sends a coded signal through two IR LEDs 1 and 2. IR light from these LEDs is reflected by a wand or hand back on to the sensor and this causes its output at pin 2 to go low.

This "low" is connected to two 7555 timers (IC2, IC3) and to PNP transistor Q1 which is used as an inverter. Selector switch S2 determines which of these three devices is connected to transistor Q2 which drives relay RLY1.

IC2 is a short time monostable to debounce the incoming signal and toggle IC4, a 4013 flipflop. Its output at pin 1 goes high and low on alternate input pulses. This is option 1.

IC3 is another monostable to give a relay closed time of about 16 seconds. This time can be varied by changing the associated resistor and capacitor. This is option 2.

In the third switch position, the inverted low from Q1 becomes a high and operates the relay for as long as the hand is held over the sensor.

A wave can be quite fast and about 10cm above the sensor, on each side of which is one IRLED – about 13mm away. The sensor is from RS Components (Cat 564-396) and the relay is from Jaycar – a 500Ω reed relay (Cat SY-4030).

The wand must be white and about 15mm in diameter. A rolled up sheet of A4 paper works well. The LED in series with the relay indicates when the relay is operating.

If your selector switch does not short circuit the contacts when between positions – ie, it is a "break-before-make" type – then you can omit diodes D4-D6. The IRLEDs should be mounted in bezels to prevent leakage of IR light to the sensor.

The 330nF capacitor is a supply bypass for IC1 and should be as close to the sensor as possible. Because the signal is coded, the circuit is immune to ambient light.

A. J. Lowe,
Bardon, Qld. ($45)

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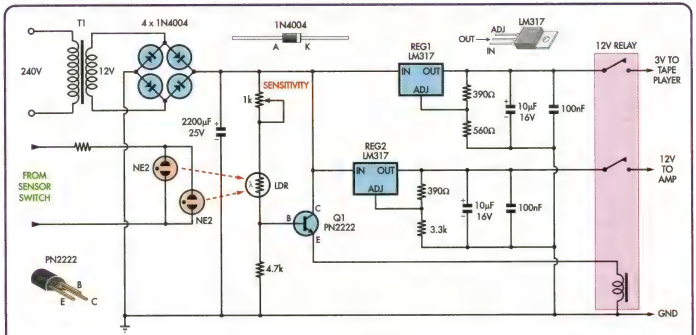
Contributions must be your own original work or a major adaptation and not published elsewhere nor submitted for publication elsewhere. SILICON CHIP's decision is final.



Automatic tape control for display stand

This circuit controls an auto-reverse Walkman cassette player, via the relay in a standard security light unit (about $20 from Kmart). These units are unsuitable for connection to inductive loads, so to overcome this and still maintain isolation from the AC supply, it is arranged so that the sensor's relay activates a pair of NE2 neons with integral resistors.

These are encased with an LDR in heatshrink tubing. The LDR switches on transistor Q1 which activates the relay. This in turn switches the supply to the cassette player which is left with the Play button permanently activated. A second set of relay contacts provides a 12V supply to an audio amplifier, fed with the signal from the Walkman.

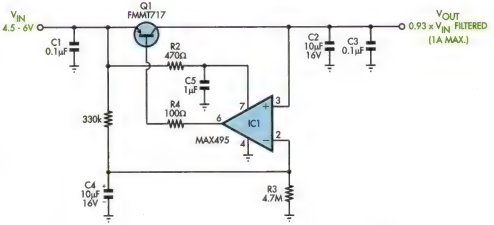
The duration of operation is set by the adjustment provided on the movement sensor which is also set for daylight operation. Two LM317 adjustable regulators provide the +12V and +3V supply rails.

Max Walker,
Blackburn, Vic. ($30)

Filter reduces supply ripple by 40dB

This circuit reduces noise and ripple voltage by 40dB over the 100Hz to 20kHz audio range. It provides a clean source of 5V power for driving audio circuits in portable applications such as cellular phones and multimedia notebook computers. Most linear regulators reject noise only up to 1kHz or so, which can be inadequate in many applications.

When operating, the circuit acts as a wide bandwidth buffered voltage follower (not a regulator) whose DC output level is 7% below the input. R1 and R3 form a voltage divider that provides the 7% attenuation while C4 provides filtering. The op amp's small input bias current (25nA typical) allows large resistor values for R1 and R3, yet limits the maximum DC error to only 20mV. The result is a low-pass filter with a 2Hz corner frequency and 20dB of attenuation at 20Hz.



The physical layout can be very small: one SOT23 transistor, one µMAX (shrink SO-8) op amp and a few passive components. The largest capacitor is 10µF and the resistors can be 0.1W or surface mount 0805 size.

Because the op amp's common mode input range extends from rail to rail, its non-inverting input can sample the output voltage directly. The op amp's supply voltage is filtered by R2 and C5, providing lower output impedance and better power supply rejection for the op amp at high frequencies. This filter's 300Hz rolloff augments the op amp's PSRR (already impressive at 110dB).

A similar article appeared in the January 18, 1996 issue of EDN magazine.

Using Linux to Share an Optus Cable Modem Internet Connection

Pt.3: masquerading modules & a firewall

In this article, we show you how to load various modules that are required for effective Internet access, along with a simple yet effective firewall. We also tell you what you need to do to connect a cable modem to Telstra Bigpond Advance instead of to Optus CableNet.

By JOHN BAGSTER

In order to effectively use your Linux box as a gateway, you need to set the machine up so that it loads some "masquerading modules" on start-up. In addition, you need to set up a firewall so everything is secure. After all, you don't want someone breaking in and taking over!

We'll get to our firewall shortly. Let's deal with the masquerading modules first.

The various masquerading modules are required so that the gateway correctly forwards IP packets for various Internet utilities on the client machines. Basically, these modules work with IP masquerading (or IP forwarding) so that it looks as though everything that's forwarded to the Internet is coming from a single machine – ie, the Linux box.

This is done by translating IP addresses from the local network into a valid Internet IP number before relaying the packets out onto the Internet. At the same time, IP masquerading translates any incoming packets into local addresses before forwarding them to the client machines.

It's all really something of a masquerade because the real IP addresses of the clients are hidden – hence the name "IP masquerading".

IP masquerading (forwarding) is carried out using a program called "ipchains" and this is also used to create the firewall rules. Recent versions of Linux also include an updated replacement for ipchains called iptables (although ipchains is still included). The firewall described here is based on ipchains (since this is used by default with RedHat 7.0) but both are supported in system startup, so you could use iptables if you want.

Note, however, that the commands for iptables are different. The differences are well documented in manual pages if you wish to convert the firewall to iptables.

Loading modules

In most cases, the firewall rules and the rules to load the various module are all in one script – ie, the firewall script. However, in this case, they have been separated into two scripts so that the firewall can be enabled before networking is enabled. Note that this not only applies to a cable modem connection – it is equally applicable to a dial-up modem.

There are quite a few masquerading modules for Linux, most of which are optional for audio, instant messaging, and various games, etc. Basically, you only need to load the modules that you require. This is roughly similar to selecting which options you want when you install Windows.

OK, so how do we ensure that these modules are loaded at start-up? The answer is that we use a file called ***rc.local*** which RedHat Linux stores in the ***/etc/rc.d*** folder. This file is the last thing executed at start-up and you can add your own commands to it.

Masquerading script: /etc/rc.d/rc.modules

```
#!/bin/bash
#
# rc.modules

# rc.modules should be called via rc.local

# Load powerswitch so Linux will shutdown neatly when switched off.
# Only works with ATX power supplies. Uncomment the following line and modify to suit
#
#/sbin/insmod /lib/modules/3rdparty/powerswitch.o

# Load all required IP masquerading modules
# Uncomment the modules you need.

/sbin/depmod -a

# Supports the proper masquerading of FTP file transfers
/sbin/modprobe ip_masq_ftp

# Supports the masquerading of RealAudio over UDP.
# Without this module, RealAudio WILL function but in
# TCP mode. This can cause a reduction in sound quality
#/sbin/modprobe ip_masq_raudio

# Supports the masquerading of IRC DCC file transfers
#/sbin/modprobe ip_masq_irc

# Supports the masquerading of Quake and QuakeWorld.
# This module is for multiple users behind a Linux gateway.
# If you are going to play Quake I, II, and III, use the second one.
# Quake I / QuakeWorld (ports 26000 and 27000) :
#/sbin/modprobe ip_masq_quake
# Quake I/II/III / QuakeWorld (ports 26000, 27000, 27910, 27960) :
#/sbin/modprobe ip_masq_quake 26000,27000,27910,27960

# Supports the masquerading of the CuSeeme video conferencing software
#/sbin/modprobe ip_masq_cuseeme

# Supports the masquerading of the VDO-live video conferencing software
#/sbin/modprobe ip_masq_vdolive
```

You could put all the module loading commands directly into the ***rc.local*** file and that would work without problems. However, it's far neater to have the commands in a separate file and then call this from ***/etc/rc.d/rc.local*** (we'll show you how shortly). We've called this separate file ***rc.modules*** and placed it in the ***/etc/rc.d*** folder.

The rc.modules file

OK, let's take a look at the ***/etc/rc.d/rc.modules*** file that you need to create. You can either download this file from the SILICON CHIP website or type it in on your Linux box using a text editor. The file is shown in the accompanying panel and contains the common masquerading modules that you might need. However, most of these have been commented out by placing a "#" at the beginning of their command lines.

All you have to do is "uncomment" the modules that you need by removing the relevant "#" symbols.

The various lines in the ***rc.modules*** file are all self-explanatory except for the "powerswitch" line. To explain, Powerswitch is a nifty little utility that shuts down Linux properly (and switches the PC off) when you press the power switch on the system case – pro-

Firewall rules: the *cablefirewall.simple* script

```
#!/bin/bash
#
# cablefirewall.simple
# run this to set up the rules, then run
# /etc/rc.d/init.d/ipchains save
# to save the rules to be used every time the machine is started

# modem interface (change to suit)
MODIF="eth1"

# local network (change to suit)
LOCNET="192.168.0.0/24"

# ============================================================================
# blocking rules for the input, output, forward chains respectively
Iblock="DENY" ; Oblock="REJECT" ; Fblock="DENY"

# Flush all existing rules and remove any user defined chains
/sbin/ipchains -F ; /sbin/ipchains -X

# loopback and local interfaces are OK on input and output
/sbin/ipchains -A input ! -i $MODIF -j ACCEPT
/sbin/ipchains -A output ! -i $MODIF -j ACCEPT

# set policies to block everything
/sbin/ipchains -P input $Iblock
/sbin/ipchains -P forward $Fblock
/sbin/ipchains -P output $Oblock

# masquerading timeouts
/sbin/ipchains -M -S 7200 10 160

# ============================================================================
# input chain:

# block and log modem interface claiming to be local network (IP spoofing)
/sbin/ipchains -A input -i $MODIF -s $LOCNET -l -j $Iblock

# allow return tcp packets (those not requesting a connection)
/sbin/ipchains -A input -p tcp -i $MODIF ! -y -j ACCEPT

# allow incoming tcp ftp-data connections (for outgoing active ftp)
/sbin/ipchains -A input -p tcp —sport ftp-data —dport 1024:65535 -i $MODIF -y -j ACCEPT

# allow all udp and icmp in
/sbin/ipchains -A input -p udp -i $MODIF -j ACCEPT
/sbin/ipchains -A input -p icmp -i $MODIF -j ACCEPT

# uncomment to reject and log anything else (required since policies can't log)
# the policy is the same so leave this line commented out if you're not logging
#/sbin/ipchains -A input -l -j $Iblock

# ============================================================================
# output chain:
```

continued next page . . .

Cablefirewall.simple – continued

```
# allow everything except local network traffic out to the modem
/sbin/ipchains -A output -i $MODIF ! -s $LOCNET ! -d $LOCNET -j ACCEPT

# set delay and throughput times if using a dial-up modem (ppp interface)
# these are not to be used if using a network card (cable modem)
if [[ $MODIF == "ppp"* ]]
then

# set minimum delays
for p in www ssh telnet ftp pop3 smtp ; do /sbin/ipchains -A output -p tcp —dport $p -t 0x01 0x10 ; done

# set ftp-data for maximum throughput
/sbin/ipchains -A output -p tcp —dport ftp-data -t 0x01 0x08
fi

# reject and log anything else (required since policies can't log)
# the policy is the same so comment this line out if you're not logging
/sbin/ipchains -A output -l -j $Oblock

# ================================================================================
# forward chain:

# Masquerade from local network to anywhere on the modem interface
/sbin/ipchains -A forward -i $MODIF -s $LOCNET -j MASQ

# all other forwarding is blocked and logged
# the policy is the same so comment this line out if you're not logging
/sbin/ipchains -A forward -l -j $Fblock
```

vided you have an ATX power supply, that is.

It's just the shot if you intend operating your Linux gateway without a mouse, monitor or keyboard.

The powerswitch module does not come with the Linux distribution. If you intend to use it, you can download it from **http://deadlock.et.tudelft.nl/~joris/powerswitch/** and install it as described in the instructions (more on this next month). In this case, the ***powerswitch.o*** file was placed in the ***/lib/modules/3rdparty*** folder (you will have to create this).

Modifying rc.local

You now have to modify ***/etc/rc.d/rc.local*** so that it calls the ***rc.modules*** file during start-up. The start of the ***rc.local*** file initially looks like this:

```
#!/bin/sh
#
# This script will be executed *after* all the
# other init scripts.
# You can put your own initialisation stuff in here if
# you don't want to do the full Sys V style init stuff.

if [ -f /etc/redhat-release ]; then
```

All you have to do is edit it to add a call to the ***/etc/rc.d/rc.modules*** file, so that it looks like this:

```
#!/bin/sh
#
# This script will be executed *after* all the
# other init scripts.
# You can put your own initialization stuff in here if
# you don't want to do the full Sys V style init stuff.

/etc/rc.d/rc.modules
if [ -f /etc/redhat-release ]; then
```

Setting up a firewall

Once ***rc.modules*** is set up, your Linux gateway is complete except for a firewall. The one described here offers good security while not compromising access to the Internet. It is about as simple as you can get and is easy to set up.

We'll look at how the various firewall rules operate first, then give the firewall script and describe how it works.

RedHat has a start-up script called ***/etc/rc.d/init.d/ipchains*** (not to be confused with the ***/sbin/ipchains*** program). This is run before networking starts and loads a saved set of firewall rules. Furthermore, to save a new set of rules, you simply run the firewall script and then type:

```
/etc/rc.d/init.d/ipchains save
```

Once you've done that, the firewall is automatically set up before any networking each time you start the Linux PC. This not only gives you full security but also saves you from having to manually modify or add any start-up scripts yourself!

To reload your saved rules you can type:

/etc/rc.d/init.d/ipchains start

and the previously saved rules are restored! Conversely, to remove all rules, you type:

/etc/rc.d/init.d/ipchains stop

This flushes all rules and removes all user-defined chains, thereby disabling the firewall. However, this will leave your PC wide open to attack, so it is not recommended.

On the other hand, typing

/etc/rc.d/init.d/ipchains panic

does the opposite – ie, it denies everything (including local network traffic). Don't do this from a local telnet or ssh connection – if you do, you will be stuck and will have to recover from the console!

Firewall rules

The firewall consists of three basic sections, called "chains": an **input chain**, an **output chain** and a **forward chain**. They can be applied to each network card in the Linux PC but all we are really concerned about here is the network card connected to the cable modem (no restrictions are usually applied to the local network card, although they could be if required).

The input chain covers anything coming in from the Internet. This is the one that the restrictions usually apply to, as you do not have any control over who or what is trying to gain access to your PC. The output chain covers anything being sent out to the Internet.

The forward chain is used to transfer packets from the input chain of your local network card to the output chain of your modem network card (ie, to send stuff from your Linux PC or one of your Windows PCs to the Internet). Anything coming back from the Internet (ie, reply packets) is simply transferred directly from the input of the modem card to the output of the internal LAN card.

A fourth type of chain is one you create yourself. This is effectively a subroutine, for want of an analogy, and would normally be used if you want to apply the same set of rules in more than one place.

Note that in ipchains, the forward chain comes from the input chain and goes to the output chain. This means that the forward chain does not usually require any specific blocking rules. Conversely, in iptables the forward chain does not traverse the input or output chains at all. As a result, it requires similar security to the output chain.

All chains can be told to DENY (DROP in iptables) or REJECT something. The difference between the two is that REJECT returns an error message (so the hacker knows what has happened) while DENY does not return any messages. This means that DENY is ideal for use with the input chain as hopefully potential crackers will give up if they get no response at all.

Another option is called ACCEPT, which means to allow something through. This is not normally used in the forward chain. Instead MASQ is used, which instructs the chain to change the internal network addresses to the external (eth1) address.

The input, output, and forward chains also have a thing called a "policy", which is simply what to do when all else fails. By contrast, user defined chains do not have a policy – they simply return to the point they were called from.

For a detailed description on ipchains (with lots of examples), go to the following Internet site:
http://www.tldp.org/HOWTO/IPCHAINS-HOWTO.html

To find out how iptables works, you can go to:
http://www.linuxguruz.org/iptables/howto/iptables-HOWTO.html

How the firewall works

OK, let's now take a look at the firewall rules listed here in **cablefirewall.simple**. We'll start from the top and describe what each rule does:

First, **MODIF="eth1"** is a variable that defines the network card your cable modem is connected to. Change the eth1 to eth0 if required, or to ppp0 if you are using a dial-up modem.

The reason for using a variable is that you can change it here and then all later references to **$MODIF** will refer to the correct network card. This saves you from having to change it throughout the whole script.

Similarly, **LOCNET="192.168.0.0/24"** refers to your internal network. The **/24** means the same thing as **/255.255.255.0**

Iblock="DENY" ; Oblock="REJECT" ; Fblock="DENY" are three statements on one line (hence the semicolons). You can change the DENYs to REJECTs and visa versa if you want. I have used DENY for the input (so crackers get no indication) and REJECT for the output so users on the internal network are warned of any problems with outgoing traffic.

Next any existing firewall rules are removed by flushing all existing rules and any user-defined chains.

The local and loopback networks are allowed for both input and output, so the loopback (required for internal Linux use) is enabled as quickly as possible. The local network is allowed to do anything, the theory being that users on your internal network are friends, not enemies! This is done by allowing everything except the cable modem interface (the "!" means "anything but").

Next, the policies for all three chains are defined to deny or reject everything. The following masquerading timeouts are standard values which are used everywhere.

The input chain is where we stop crackers getting in. Here, crackers who are devious enough to supply an

Connecting To Telstra Bigpond Advance

Unlike OptusNet cable, Telstra Bigpond Advance requires a login script for full Internet access. Under Linux, this login script is called ***bpalogin*** and several readers have asked for further information on how this is installed. Although we haven't tested it, the following procedure should work:

(1) Go to **http://bpalogin.sourceforge.net/**, then click the "Download BPAlogin" link and select the download you require - eg, "RedHat Linux RPMs v2.0". The **bpalogin-2.0-1.i386.rpm** file that's download is about 170Kb in length.

(2) Copy this file to the Linux PC and install it by typing:

rpm -i bpalogin-2.0-1.i386.rpm

This creates the following files and directories (as shown by rpm -q -p -l bpalogin-2.0-1.i386.rpm):

/etc/bpalogin.conf
/etc/rc.d/init.d/bpalogin
/usr/doc/bpalogin-2.0
/usr/doc/bpalogin-2.0/COPYING
/usr/doc/bpalogin-2.0/CREDITS
/usr/doc/bpalogin-2.0/INSTALL
/usr/doc/bpalogin-2.0/README
/usr/sbin/bpalogin

(3) Open **/etc/bpalogin.conf** in a text editor and change the following two lines (near the top of the file):

username yourname
password yourpass

You obviously set "yourname" and "yourpass" to whatever your Bigpond Advance user name and password are.
I notice that the file is set to -rwx------ and is owned by root, so it already is protected against unwanted peaking.
The start of the file looks like this:

 # Default debug level is 1. Values range from 0-2
 # with 0 being silent
 # All information goes to the syslog.
debuglevel 1

 # The user name you have for your BPA account
username yourname

 # Your BPA password
password yourpass

Note that there is also a ***/etc/rc.d/init.d/bpalogin*** start-stop script. Now type:

chkconfig --list bpalogin

This shows that the rpm installation sets the startup and shutdown as follows:

bpalogin 0:off 1:off 2:off 3:on 4:on 5:on 6:off

This means that after editing ***/etc/bpalogin.conf***, you can start ***bpalogin*** either by restarting Linux or by typing:

/etc/rc.d/init.d/bpalogin start

internal IP address to try to get through are stopped.

Now the important one. Anybody trying to break in must be stopped but you have to be able to get stuff back from the Internet yourself. The next line achieves this by allowing TCP traffic that is not a connection (ie, it allows return packets).

One problem with this is that when you download data using FTP, it requires a connection! So the next line defines a rule that allows FTP data connections only.

Next we allow UDP and ICMP packets in. UDP is used by DHCP and DNS, while ICMP is used for error messages, pings, etc. This does mean that crackers can ping the PC but it is possible to prevent this by setting up several ICMP rules, to be selective.

The last input chain rule blocks and logs anything else, so you can check who or what is trying to break in. This is only required if you want to log any blockages. Since the only thing being blocked is TCP connections, which you should never allow anyway, this line is commented out.

If you do want to log TCP blockages then remove the "#" from the start of the line.

The output chain is a lot simpler. Everything is allowed out to the cable modem, except internal IP addresses. This is a simple safeguard in case you make a mistake configuring any of the services on your local network.

Next are some delay rules which only apply to a dial-up modem (delays are optimised for a network card by default). A test is done for the external interface being ppp* (ie, a modem).

The last thing is to block and log everything else. Since the output chain policy is to block, you can remove this if you do not want to log anything but that would not be a good idea. Anything logged here will be something you will need to fix.

The forward chain is also quite simple and has just

two rules. First, internal IP addresses are changed (masqueraded) to the cable modem's IP address. Everything else is then logged and blocked. Again, if anything is logged here, it will be a problem you need to fix.

Making the firewall work

To get the firewall rules up and running, you must have IP forwarding enabled as described in Pt.1. The local and cable modem networks will also be up and running at this stage. Note, however, that this means that the PC is wide open to attack, so have the firewall ready to roll if you are starting with the cable modem plugged in.

Actually, only the local network needs to be up for IP forwarding to be enabled, so a better scheme would be to unplug your cable modem before starting the PC. In fact, this is the recommended method as it will keep you safe while you install the firewall.

You can either type **cablefirewall.simple** in yourself or, better still, save yourself the hassle by downloading the script from the SILICON CHIP website at: **www.siliconchip.com.au**

It doesn't really matter where you save it since it is only run once to initially set the rules up before they are saved (see below). However, **/usr/local/bin** is probably as good a place as any to store the firewall script.

It's then just a matter of running the script to activate the rules. You do that by typing:

```
/usr/local/bin/cablefirewall.simple
```

Note that if you have the cable modem unplugged, this script will take a while to run but it will get there. Follow this by typing:

```
/etc/rc.d/init.d/ipchains save
```

This command saves the firewall rules so that they are now automatically invoked on system startup, before networking is enabled. This gives you full security.

By contrast, if **/etc.rc.d/cablefirewall.simple** was called from **/etc/rc.d/rc.local**, then the networking would be up long before the firewall was. And that could create security problems.

The interesting thing here is that the saved rules will be restored before IP forwarding is enabled without a problem. However, trying to set the rules via **cablefirewall.simple** without IP forwarding enabled won't work! Note that this isn't a problem with **cablefirewall.simple** – it's simply the way ipchains works.

Assuming that you unplugged your cable modem for security, you can now plug it back in and type:

```
ifup eth1
```

This will start the cable modem network. Don't forget to use eth0 instead of eth1 if this is the cable modem interface.

And that's it. If you've followed all the instructions so far, you will now have a working Internet gateway, firewall, DHCP server and DNS server.

In Pt.4, we will describe a script to enable easy viewing of any firewall logs and show you how to run your Linux box without a screen or keyboard, including shutting it down via the power switch (if it has an ATX power supply). We'll also briefly discuss a few security safeguards. **SC**

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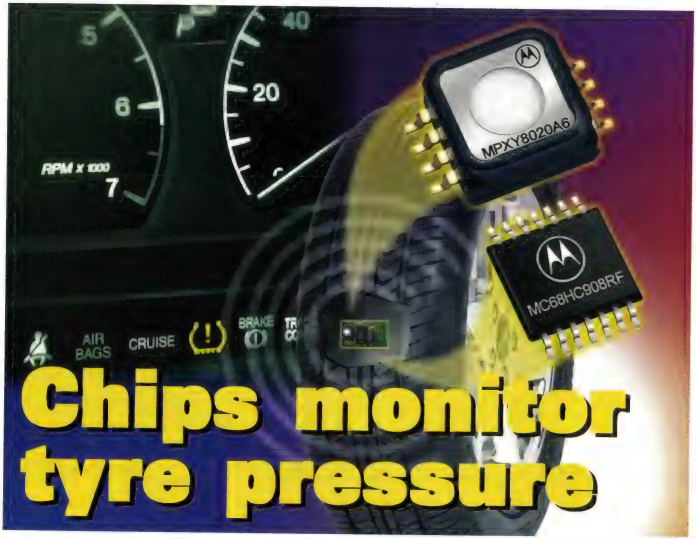


Chips monitor tyre pressure

US electronics giant Motorola is set to introduce computers into the last electronics-free zone in a car – its tyres. The company has developed a two-chip remote sensing module (RSM) small enough and light enough to fit inside a tyre without unbalancing the wheel.

A **sensor chip**, code-named Daytona, measures pressure to within 7.5kPa (typical car tyre pressure is 220kPa), and temperature to within 4° Celsius. Temperature measurement is necessary to compensate for pressure changes due to tyre heating during driving.

The Daytona chip is fabricated using low power CMOS technology and draws just 0.55μA on standby. The second chip in the RSM is a combination of Motorola's HC08 microcon-troller and a UHF radio transmitter in a 32-pin package. It processes the raw measurements into a tyre pressure reading and transmits the data to the in-car receiver.

The transmitter operates in the 315, 434 or 868MHz bands, sending the pressure data at up to 9600 baud by either on/off or phase shift keying. The HC08 has 2Kb of on-board FLASH memory and enough I/O and computing power to handle the pressure and temperature reading task.

It also has built-in power management capabilities to get the most out of the lithium battery powering the module. When the car is parked, an inertial switch can be used to turn off the transmitter and leave the HC08 in low power sleep mode.

By PETER HOLTHAM

These power-saving features of the RSM will ensure a battery life of at least ten years. A simple PC board antenna completes the RSM hardware. It provides a signal strong enough to be picked up by the receiver inside the car.

Making the module is one thing, keeping it alive in the harsh environment inside a tyre is another. Temperatures can range from a freezing -40°C to a scorching 150°C . The RSM is also subjected to accelerations as high as 2000G as the wheels rotate.

The computer and transmitter can be protected but the pressure sensor must be in contact with the air in the tyre. Motorola engineers have devel-

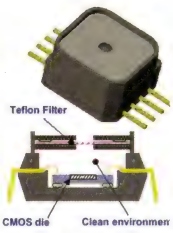
oped a special Teflon filter to protect it against attack by liquids, dust, and corrosive gases.

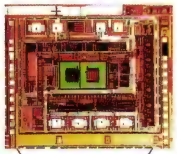
The tyre pressure signal is picked up inside the car with the same receiver already installed for remote keyless entry.

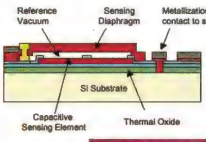
The information presented to the driver will depend on the software programmed into the HC08 and the receiver by car component suppliers. It could be as simple as a dashboard warning light showing that one of the five tyres (including the spare) needs pumping up.

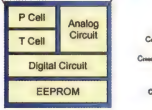
More complex systems will automatically identify each tyre and provide the exact pressure. Motorola plans to begin volume production of RSMs in September this year. The price will depend on end-user requirements and will vary based on volumes and specifications. But with around 50 million cars produced every year, demand for remote tyre pressure monitoring is expected to soar, driving prices down.

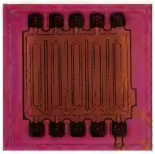
All of which means monitors are likely to become standard equipment within the next few years.











Other Manufacturers Join The Fray

Given the huge global market for new cars, Motorola was not going to be left as the sole supplier of tyre pressure monitors for long.

Now European electronics company Philips has launched a rival chip to assist in the measurement of individual tyre pressures.

The P2SC signal-conditioner works together with pressure sensors built into the tyre. It mounts directly on the tyre rim, providing a wireless link to transmit the pressure to the keyless entry receiver in the car.

The monitor inside the car sends a low frequency 'wake-up' signal to each P2SC chip every time the ignition is switched on. The chip returns pressure information at frequencies in the 315 and 434MHz bands.

While the car is being driven, the P2SC chips send regular status reports on each tyre back to the driver.

The low frequency wake-up also allows the monitor to automatically identify which tyre is where; even after tyre position is changed during maintenance.

Industry analysts expect pressure monitors to become the fastest growing segment of car electronics over the next few years. **SC**

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VINTAGE RADIO

By RODNEY CHAMPNESS, VK3UG

Intermediate Frequency (IF) Amplifiers; Pt.2

Last month, we looked at how the IF stage evolved in early broadcast-band AM radios. This month, we look at high-fidelity IF amplifier stages and describe how to get rid of the 9/10kHz whistle.

PRIOR TO THE introduction of FM into Australia, some radio manufacturers produced receivers that were capable of reproducing the full transmitted audio bandwidth. Typically, this involved designing 20kHz IF (intermediate frequency) stages to give a maximum audio frequency response of 10kHz.

However, the use of a wide-bandwidth IF laid the receiver open to annoying "monkey-chatter" – ie, distorted modulated audio signals from stations close to the tuned frequency. It also gave rise to annoying 10kHz heterodyne whistles from stations on adjoining channels. The monkey chatter couldn't be eliminated but the 10kHz whistle could be and often was.

Basically, the 10kHz whistle was "eliminated" by installing a simple 10kHz audio notch filter. This filter effectively reduced the whistle to an insignificant level.

The 10kHz filter often took the form of a narrow-band rejection filter, as shown in Fig.1. In this case, the filter is physically tuned to 10kHz by varying L1 or C1 and C2, while the depth of the notch was adjusted by VR1. Note that, with the advent of 9kHz channel spacing, these filters had to be retuned from 10kHz to 9kHz.

Variable selectivity IF stages

In most cases, broadband amplifiers did a good job on local stations and gave an audio output which was considered high-fidelity at the time (10kHz compared to FM which has frequencies as high as 15kHz). However, listening to more distant stations was often quite unpleasant at night, due to fading, noise and interference, monkey chatter and 10kHz heterodynes.

To counter these extremely annoying problems, most high-fidelity receivers included a switch that reduced the IF amplifier bandwidth to around 10kHz. This meant that the receiver could produce audio signals up to only about 5kHz when the switch was in the "narrow" position.

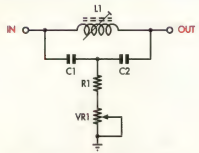

Fig.1: the circuit for a 9/10kHz audio notch filter. It is designed to filter out 9kHz or 10kHz whistles (depending on the station spacing) in a wideband AM receiver.

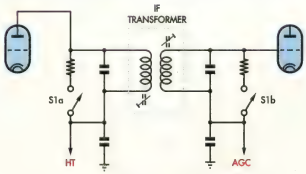

Fig.2: a variable bandwidth IF stage. Switching the resistors across the IF transformer windings increased the bandwidth, while reducing the gain of the amplifier.

This photo shows an assortment of 455kHz IF transformers. They came in a wide range of sizes.

Of course, this meant that the full frequency range was no longer reproduced, so listeners had to be content with less than "hifi" reproduction. However, on the positive side, the 10kHz whistles, monkey chatter, noise and interference were all significantly reduced. This was important because before the advent of TV, the evening's entertainment often involved listening to the radio.

Variable bandwidth

Taking this a step further, some manufacturers designed variable bandwidth IF stages that could be switched to suit the listeners' requirements. This was done in a variety of ways.

One method involved switching resistors across the IF transformer windings. This lowered the Q of the windings and the gain of the amplifier, while at the same time increasing the bandwidth of the amplifier – see Fig.2. Another method involved removing one IF transformer completely, replacing it with an untuned inductance-capacitance network.

Still another method involved switching a tertiary winding in and out of circuit in a special IF transformer. There were even circuits which automatically adjusted the bandwidth according to the strength of the received signal – ie, the bandwidth was controlled by the AGC.

However, although such circuits were around, very few showed up in the average domestic receiver. It's also interesting to note that specialised high-fidelity tuners/receivers often used an IF of 1900kHz (or some other frequency above the broadcast band) to achieve good bandpass shape and 20kHz bandwidth.

Unfortunately, fading – and selective fading in particular – remained as a severe impediment to good quality reception on distant stations. For those unfamiliar with selective fading, it manifests itself as severe distortion and fading of the received signal. It is usually due to multi-path reception, which causes the relative levels and phase of the carrier and its two sidebands to vary.

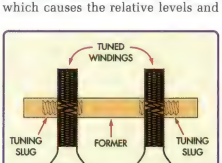

Fig.3: this diagram shows the correct positions for the slugs in an IF transformer. Note that the coils are tuned with the slugs towards the outside ends of the former (not in the centre).

Keeping IF amplifiers stable

It is rare to have instability and oscillation problems in well-designed amplifier stages. By using an IF of 455kHz and normal high-gain IF transformers, a valve with a mutual conductance of around 2000 was all that was necessary to obtain the necessary performance. Valves such as the 6U7G and the 6N8 fall into this category.

To ensure stability under all circumstances, it is necessary to make sure that the layout of the amplifier is such that inputs and outputs are kept well apart. This particularly applies if using high-gain valves. In some cases, such as when using high-gain valves like the 6BA6 (and more so with the 6AU6), a shield may need to be soldered across the valve socket, isolating the input from the output. As a matter of interest, I've found a number of Healing sets using the 6AU6 to be marginally stable.

Neutralisation

Neutralisation was used in circuit design back in the 1920s when triodes were used as RF amplifiers. It was necessary if reasonable gain was to be obtained without the amplifier oscillating. However, with the advent of RF tetrode and pentode valves, neu-

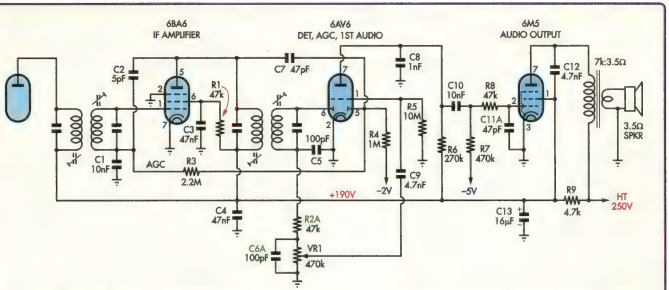

Fig.4: typical IF, detector and audio stages for an AM broadcast band receiver. The components marked with an "A" suffix are often missing but their inclusion improves performance (see text).

tralisation became unnecessary in most circuits, particularly in IF amplifiers with their relatively lower frequency of operation compared to RF amplifiers.

However, I've found that EMI/HMV have been sticklers for doing things right. Fig.4 shows a circuit in which the IF stage is approximately neutralised. The 5pF (C2) capacitor from the plate of the 6BA6 to the bottom of the secondary of the IF transformer acts with the AGC bypass (C1) to form a bridge neutralising circuit.

I had a Little Nipper receiver to restore some time back which had an unstable IF amplifier – it tended to oscillate if I wasn't careful with the alignment. It turned out that someone had been at the set before it came to me and had replaced the .01µF AGC bypass capacitor (C1) with a value of 0.1µF. Replacing this capacitor with the correct value restored the neutralisation and the IF stage was again quite stable.

Detector & AGC leads

The leads from the detector and the AGC diode tend to be treated as having no RF energy on them. In reality, however, they carry quite a bit of RF (IF) energy and this needs to be prevented from radiating and causing instability within the receiver.

For example, resistors R3 and R4 should have minimal lead length on the ends connecting to pin 5 of the 6AV6. Similarly, the 47pF capacitor (C7) lead from pin 5 of the 6BA6 should be as short as possible, as should C5's lead on the IF transformer terminal. By observing these precautions, minimal IF energy will be radiated from the IF amplifier circuits.

The detector lead to the volume control can also radiate energy if it isn't shielded. However, few receivers in the later valve radios have this lead shielded so it isn't always necessary. Note too that some receivers have the volume control directly connected to the bottom of the IF coil as shown in Fig.4 (assuming that R2A is a wire link). In that case, only the 100pF bypass capacitor (C5) provides RF filtering.

By contrast, the better receivers include another section of filtering based on resistor R2A and capacitor C6A. This further reduces the level of RF (IF) energy getting through to the audio amplifier.

Although the audio amplifier favours audio frequencies, it also amplifies any IF signals that find their way into this stage. This signal can then be radiated from the audio amplifier and picked up by the front-end of the receiver, or by other receivers nearby, where it can cause some strange effects.

In some cases, this radiation causes the receiver to perform poorly at the low-frequency end of the broadcast band. It's difficult to describe the exact symptoms. However, the set doesn't have the sensitivity it should and also seems to be a little strange in its alignment, with a certain amount of "swish" heard as the set is tuned across a station.

So what can be done to overcome this problem. The amount of IF signal getting into the audio amplifier has already been reduced by the filter consisting of R2A and C6A. In addition, capacitor C8 from the plate of the 6AV6 to earth also reduces the amount of IF energy in the circuit.

However, if the lead lengths from the plate of the 6AV6 to the grid of the 6M5 are short, it would be better to connect a small-value capacitor (such as C11A) between the grid of the 6M5 and earth. The combination of R8 and C11A would then be more effective at reducing the IF energy applied to the grid of the 6M5 than using just C8.

Most output stages have a capacitor from the plate to chassis or to the high voltage supply. This reduces the amount of IF energy at the output of the audio amplifier, as well as acting as a mild top-cut audio filter. The suggested added components that reduce this problem are shown with an "A" after them in Fig.4 (R2A is normally a short circuit in most sets). By carrying out these modifications, I've found that many receivers offer improved performance.

Another set I looked at some time ago had an extremely unstable IF amplifier. It didn't take long to establish that RF signals were being amplified in the audio stage and were being fed

back through the set. In fact, it was so unstable that even bringing the plastic handle of a screwdriver near some of the normal supply wiring caused the set to either go into oscillation or to stop oscillating, depending on the state it was in at the time.

In this case, the problem was found to be lack of proper filtering of the high-tension (HT) supply line. In this particular receiver (from a well-known manufacturer), R9 was not included in the circuit design – there was just a length of wire where a resistor could (should) have been. I decided to decouple the HT line by installing a resistor in this location and the set immediately became stable and proved to be a really hot performer.

Problems can also occur when IF cans are not earthed properly or a shield can is missing from a valve. These are problems that are easily fixed.

Despite a few problems, I have generally found IF amplifiers to be quite reliable. In most cases, all that is necessary to restore the performance is to replace leaky paper capacitors and perhaps the odd valve. The AGC bypass capacitor(s) are particularly important and these should have no discernible leakage. If they do, the normal AGC control voltage will not be applied and this usually results in overloading of the IF amplifier.

An IF amplifier with low gain

It's important that IF transformers be wired the correct way, as reversing the connections on one winding can cause the gain to be quite low. Many replacement IF transformers, such as those produced by Aegis, have the connections marked on the can, so they are easy to identify.

For unmarked transformers (eg, those salvaged from derelict receivers), the windings can usually be identified by taking the transformer out of its shield can. The grid winding is the one furthest from the base. If the performance is poor and you know the transformer is good, try reversing the connections. Also, if an IF transformer is being taken out of a wreck, observe what each lead is attached to and label the leads accordingly.

The following information from the 4th edition of the Radiotron Designer's Handbook (by Langford-Smith) will help in identifying IF transformer windings: "For the capacitance and mutual inductance coupling to be aiding, the primary and secondary windings are arranged so that if the plate connects to the start of the primary, then the grid (or diode plate) of the next stage connects to the finish of the secondary winding; both coils being wound in the same direction . . . the grid and plate connections should be as far from one another as possible".

Aligning the IF amplifier

The standard IF transformer usually has critical coupling between the two tuned circuits. Critical coupling provides maximum gain with the transformer adjusted by simply tuning for a peak.

IF transformers employ a variety of methods when it comes to adjusting the slug-tuned types. Older types have an earthed metal screw thread which can be adjusted with a normal metal screwdriver. Conversely, if the tuning tool has to be inserted into the IF

A selection of plastic alignment tools will be necessary if you intend restoring vintage receivers.

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Photo Gallery: Eclipse Monarch DKL

Manufactured by Eclipse Radio (Melbourne), the 1947 Monarch DKL is a good example of the 4-valve reflex superhet designs that were popular during that period. The set was available in a number of different cabinet colours, including white as shown here. The following valves were used: 6A8-G frequency changer; 6B8-G IF amplifier/reflexed 1st audio/detector/AVC amplifier; 6V6-GT output; and 5Y3-GT rectifier. (Photo and information courtesy Historical Radio Society Of Australia).

transformer, you use a non-metallic alignment tool.

It is also important to use the right tool here for two reasons: (1) so that the slugs are not damaged; and (2) so that the transformer is not detuned by the presence of a metallic adjustment tool. Plastic alignment tool kits are available from various electronics stores or you can use knitting needles which have their ends filed to a screwdriver blade shape.

The older type IF transformers that use trimmer capacitors across the tuned winding are also best adjusted with a plastic alignment tool. That's because the plate voltage (ie, the HT) is usually present on at least one trimmer – use a metal tool and you could get a nasty shock.

The alignment procedure is as follows: first, with the set turned off, connect a digital multimeter (DMM) across C1 on the AGC line and switch to the 0-20V range. That done, connect a signal generator to the antenna terminals of your set and tune the set to the low-frequency end of the broadcast band.

The next step is to apply a high-level signal modulated at 1kHz at around the expected IF frequency and tune the generator across the band. If the set hasn't had its IF tuning adjustments fiddled with, a response should be heard at or near 455kHz (or what ever the nominal IF of the set is).

If the signal through the set is quite strong, the DMM will register an extra -2V along the AGC line. Adjust the output of the generator so that only -1V or so of extra voltage is shown on the meter.

If the frequency is some way away from the expected IF (eg, 20-30kHz), it is possible to "walk" the IF adjustments onto the required frequency. To do this, first tune the signal generator just to the side of the spot where the maximum response is (ie, towards the wanted frequency). That done, adjust each of the IF slugs for a peak, then go through the whole procedure again until the maximum response is at 455kHz (if this is the target frequency).

Now it is necessary to accurately tune the IF amplifier. Once again, adjust the signal generator so that the DMM reads a volt or so above the standing bias on the AGC line. Adjust each of the internal slugs or external screws for a maximum reading on the DMM, except for the tuned winding going to the detector diode. This one, at the top of the transformer, is adjusted for maximum audio, not maximum meter reading.

If the DMM is connected across the volume control (VR1), peak all adjustments for a maximum reading. Reduce the generator signal level if the DMM reading is above about -4V, as the IF amplifier tunes (peaks) slightly differently with a strong signal compared to a weak signal. Note that for best performance on weak signals, it is necessary to align the set on weak signals.

Note particularly that the slugs or screws should adjust to the correct frequency with the slugs and screws away from the centre of the former, as shown in Fig.3. If they are close together (ie, towards the centre of the former), the coupling between the two tuned circuits will be upset and the performance will be compromised.

If you don't have a signal generator it's still possible to align the set, although not quite as accurately. Once again the DMM is connected to either the AGC line or to the detector output.

All you have to do then is tune to a relatively weak station and peak the signals as described in the previous paragraph. Of course, you won't know if the IF stage is tuned to exactly 455kHz but that doesn't really matter. Note that this job should be done in the middle of the day, to avoid signal fading which would make it difficult to accurately align the IF amplifier.

So there you have it – a straightforward method of tuning the IF amplifier stages in most sets. In times gone by, when high impedance voltmeters were scarce, the audio output was measured and the IF adjustments peaked for maximum audio. However, I believe that the method I've described is more appropriate today as it also gives an idea as to whether the AGC system is working as it should.

Occasionally, one slug in an IF transformer will be stuck. If you strike this, don't force it as broken slugs are hard to get out. Instead, just adjust all the other slugs so that all tuned circuits are on the same frequency as the circuit that's tuned by the stuck slug. Being precisely on 455kHz isn't at all necessary.

Finally, for anyone who wants to know more about IF amplifiers, take a look at the relevant chapters in the "Radiotron Designer's Handbook" by Langford-Smith. SC

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Cheap 12V power supply wanted

I want a power supply to convert 240VAC from the power point to 12V DC at 3A. I am currently using a car battery but that is inconvenient. (D. F., via email).

● The cheapest way to get a high current 12V power supply is to obtain a computer power supply and tie all the +12V output leads together and all the 0V leads together (ie, connect the 12V outputs in parallel). We have not done a project along these lines.

Problems with LP Doctor kit

I recently completed construction of the LP Doctor (SILICON CHIP, January 2001) kit but now I find several problems that defy repair. In the "bypass" switch position, the straight through phono preamp and output level control work perfectly, however in any of the "processed" switch positions, there is no audio output.

I also notice that the left/right LEDs appear to function normally, although they flash regardless of the selector switch position. Is this normal? I have thoroughly checked my work and can see no apparent error. I have also successfully completed the voltage adjustment as outlined in the construction manual. Can you offer any advice? (F. S., Ingham, Qld).

● It is normal for the click detection LEDs to operate independently to the selector switch. The signal is somehow being lost through IC3, IC7 IC4, IC8, etc. Check the supply to each of the IC3 and IC7 delays and op amps IC5a and IC7a. Also check that there is -7.5V at pin 2 of IC4 and IC8.

Alternatively, the wiring to switch S2 is incorrect. Check that there is audio signal directly at the outputs of IC5a and IC7a.

10-channel remote receiver queries

The following queries relate to the 10-Channel IR Remote Receiver published in the February 2002 issue. Firstly, in forcing IC1 to display its remote control status by connecting pin 1 to the 5V supply (TP2) via a 220Ω test resistor at power up, can the same be achieved by connecting the two stakes (TP1 & TP2) on the completed board? Or should another resistor be employed, so that LED11 does not blow (ie, does the 100kΩ resistor take enough of the current)? Is this resistor best connected from TP2 straight into the terminal contacts of pin 1 with IC1 in place.

Secondly, is the decoded signal at TP2 for all signals received or only those matching Sat1/Sat2 codes? Thirdly, if the use for some outputs is currently unknown, is it OK to just leave out the 1.8kΩ resistor, which selects toggle or momentary, or do some other parts need to be left out too? (eg, respective transistor).

Fourthly, is there a part that comprises a variable resistor on a reversible motor for volume control? What would happen if power is supplied to both directions at once; ie, both buttons are pressed down by the remote user or would only signal for one button be sent from the remote? (D. K., via email).

● TP1 cannot be directly connected to TP2 or the LED (LED1) will have 5V across it with no current limiting and consequently it will be destroyed. This is why we use a 220Ω resistor at pin 1 to TP2 instead. Connecting a 220Ω resistor between TP1 and TP2 will not bring pin 1 of IC1 high enough as it will be at about 1.8-2V as set by the LED voltage.

The decoded signal at TP1 will reflect the incoming code sent by the IR transmitter. The code does not have to be SAT1 or SAT2 but the 10 outputs will not respond unless the code is correct.

The 1.8kΩ resistors on the outputs need to be connected to set the momentary or toggle option. If these are left out of circuit, the output could be either option, depending on what level the pins float at when powered up. Generally, the RA outputs will be set at momentary and the RB outputs for Toggle if no resistor is connected.

The decoder can only respond to one code at a time and so driving the

Adjusting mixture on a VR Commodore

I have just purchased a Fuel Mixture Display kit. If the vehicle is running rich, is it possible to adjust the vehicle's computer to make it run in the correct mixture range? For a VR Commodore, is there room for adjustment to make it run lean? (D. G., via email).

● Although it's possible to change the "chip" in the engine management computer (eg, to alter the timing curve and/or to change mixture settings), this really is a job for the specialist. And generally speaking, it's difficult to do better than the manufacturer's original chip.

If the fuel mixture display indicates that the engine in your VR Commodore is running rich, then there are two possibilities: (1) either the fuel mixture display is incorrectly calibrated; or (2) there is a fault in your vehicle's fuel system which should be corrected by a specialist service outlet.

Note that there are times when the engine should run rich – eg, under acceleration. If your vehicle is performing normally, then it's likely that the fuel system is operating correctly. Note also that the VR Commodore also runs quite lean when at speed under light throttle settings. It can return very good fuel economy on a trip.

SuperCharger vs Multi-Purpose Fast Charger

I have read the SuperCharger articles with interest and I am keen to build one, if you can first answer a couple of questions. I have been using your Multi-Purpose Fast Charger II for quite some time now. It has charged quite a few of the new high capacity batteries (AA 1800mAh) and seems to do it well.

What is the difference between the two chargers in their ability to charge the new high capacity batteries and am I doing my batteries harm by using the Fast Charger?

I always refresh before charge. The standard number of AA cells I charge is four; ie, 4.8V. I always use the thermistor when charging and have never had any problems with overcharged or overheated batteries.

One advantage of the new charger is it could be used away from a 240VAC power source which is attractive when using a digital camera on motoring or camping holidays. (C. N., via email).

● There are a few potential problems charging small (AA/AAA) cells with the Multipurpose Fast Charger II. Of most concern is its high fixed charge rate. You may find that you can charge Nicads at this rate (using the thermistor for temperature sensing) but it will depend greatly on the type of battery. Look specifically for "high discharge rate" types, intended for R/C applications and the like.

For NiMH-chemistry types, we're not aware of any small (AA/AAA) types that can be safely charged at 6A. You mention that you are currently doing this without problems. While it's true that thermistor temperature sensing should prevent catastrophic cell failure, we doubt that the cells will be fully-charged before the charge terminates. You may like to verify this by doing a cell capacity test.

We may publish a simple "add-on" circuit for the Multipurpose Fast Charger that allows you to reduce the charge current at the flick of a switch. No promises though!

motorised potentiometer using the two outputs will not cause any problems. And no problems occur if outputs are in any state as the motor will only have power (with either polarity) or have no power with the motor terminals both at positive or both at ground.

Delayed audio on parliament broadcast

I am interested in politics and enjoy watching the daily broadcast, when parliament is sitting, of Question Time on ABC-TV between 2:00pm & 3:00pm. Normally, when ABC-TV is broadcasting the House of Representatives, ABC NewsRadio broadcasts the entire day's proceeding from the Senate and vice versa.

However, on some occasions, both the TV and radio broadcasts were from the same House (in this case, the House of Representatives). On such occasions, when I have the TV on and also try to listen to the proceedings of the same House on the radio, I notice that there is a delay of a few seconds in the audio between the TV & radio broadcast.

Can you explain the reason or reasons for this delay? I can only assume that it may have something to do with the physics of the propagation of radio waves as, I suspect, both transmissions here in Canberra come from local transmitters. I suppose another question might be should there be a delay in the reception of the audio for a simulcast program received on both TV and radio? (P. M., Queanbeyan, NSW).

● The delay has nothing to do with the propagation of radio waves and everything to do with the way the ABC routes signals between its various studios and transmitters.

We would guess that the TV signals come direct from Canberra to the relevant station transmitter while the audio signal may go via the ABC radio studios in Adelaide (or wherever). There may even be a satellite link involved.

Mic for measuring frequency response

I would like to know if there is a cheap way of making a microphone and (preamp) with a known frequency response, to use in conjunction with the RTA spectrum analyser shown in the August 2002 issue. If not, I believe it would make a great project because being able to see the problem areas in the frequency response of a sound system setup would be very handy.

I know you can buy calibrated microphones but these all seem to be quite expensive and for the small amount of use they might get places them out of reach of most people.

Could SILICON CHIP do a project using an easy to get and cheap electret microphone and plot its response, etc, to use with RTA software? (B. B., Runaway Bay, Qld).

● Producing a calibrated microphone is not a simple task – we have looked at it as a project but cannot see an easy way of doing it.

Faulty speed control blows FETs

I have built two 20A Speed Control kits from the June 1997 issue. One works OK while the other worked for one week and then the battery was put in reverse polarity. It blew one FET.

I replaced the faulty parts and it worked for one week and then both FETs blew. I replaced both FETs but now I can't vary the speed – always near flat out. (S. G., via email).

● Strictly speaking, the circuit should not have been damaged by battery reversal. The fuse should have blown with diode D1 forward biased.

However, since the FETs were destroyed, it may be that the transistors and IC were also damaged. This would explain the full-speed only operation. It may be wise to replace the FETs, transistors, IC1 and the regulator, plus the diodes at the battery supply and across the motor.

ETI pH meter wanted

In the December 1980 issue of ETI a digital pH meter project was featured. This used an Intersil 7106 driver and a 3.5-digit LAD204 display. Do you know if this display is still available? The driver and display were sold by Intersil as part of an evaluation kit. Perhaps an updated version of the pH meter could be considered as a SILICON CHIP project? (T. S., via email).

● The ETI pH meter is no longer available. SILICON CHIP described a pH meter based on an LM324 quad op amp and an analog meter, in the April 1988 issue. It would probably be much easier to source the parts for it but you would need to make sure you could get pH electrode before proceeding further.

We can supply a photostat copy of the April 1988 article for $10, including airmail postage.

Splitting a line level signal

Could you please advise me, if I split a line level stereo output signal (left & right channel) using two "RCA Y adaptors", will it affect the level/quality of the input signal at either of the destination components (power amplifiers in this case)? G. M., via email).

● That's not an easy question to answer. Superficially, it would seem that splitting line level signals would not cause a problem but there are a number of factors to consider.

Factor one is the input impedance of the amplifiers, etc. Normally, this will be high and should not cause a problem but if it is low (say below 5kΩ), it could reduce the signal level, as well as degrade the frequency response and distortion performance.

Two, if one of the amplifiers is driven into overload, the resulting distortion artefacts may be superimposed on the line signal to the other destination device.

Three, if one of the destination devices and the signal source is earthed via the mains (rather than double-insulated) an earth loop will result which again could degrade the performance.

From this, you will see that we are not keen on Y-connectors. Provided the input impedances of your two destination devices are high, a better way is to make up a splitter box with RCA connectors and feed the signal to the two devices via isolating resistors of, say, 4.7kΩ. That way, if something naughty happens in one destination device (say overload), it won't degrade the rest of the signal chain.

Hum in Plastic Power amplifier

I have built the Plastic Power amplifier module described in the April 1996 issue of SILICON CHIP and it passed all the tests. However, I am getting hum. When I turn the power supply off, the hum stops and the amplifier continues to function for about 10 seconds or so.

Do you have any suggestions to get rid of the hum or would bigger filter capacitors do the job? (S. G., via email).

● The hum could be due to the filter capacitor value not being sufficiently large but this is unlikely. Instead, hum at low levels is more likely due to a hum loop, due to the ground connections not being connected to the one point.

To minimise hum, the ground connections for the capacitors should all connect to a single point with the 0V wiring from the transformer also connecting to this point. The amplifier output (speaker) ground then connects to this common ground. The input ground of the amplifier is not connected to the common ground as this is connected to the speaker ground on the PC board.

In addition, the rectifier (+) and (-) outputs should connect to the capacitors first, with the amplifier supply rails connecting to the capacitor leads rather than the rectifier terminals. Use heavy gauge wiring for these power supply connections.

Generating different audio tones

I am about to start a project that requires two different audio tones, one having a positive sound like a "ping", the other having a negative sound like "baamp". If you imagine, like a board game that has "yes" and "no" answers.

I would like to know what I need for creating these two tones. I want to be able to trigger each tone with a microcontroller. (B. C., via email).

● We suggest using Twin-T oscillators set to different frequencies and also set just below the point of oscillation; they can then be shocked into oscillation by a short pulse.

SILICON CHIP has not published anything on this subject but there were two relevant articles in EA: "Electronic Bongos" in December 1979 and "Twin-T Oscillators" in May 1976. We can supply photostats of these articles for $8.80 each, including postage.

How to suppress contact arcing

I have a question about how to reduce the arcing across relay contacts. I'm switching a 240VAC 1A solenoid with a 24V DC relay. What is more reliable, using a Triac or relay? (Y. G., via email).

● The normal way to suppress contact arcing when switching DC is to use a reverse-biased diode with a cur-

WARNING!

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Notes & Errata

40W Fluorescent Inverter, September 2002: Mosfets Q1 & Q2 have been found to be prone to overheating when the PC board is placed within the confines of a slimline 36W fluorescent tube batten. To correct this, the inverter has been altered to improve efficiency without reducing the lamp brightness.

Changes include reducing the 334V DC supply to 280V and winding transformer T1 differently.

The voltage change requires replacing one of the 270kΩ resistors leading to pin 1 of IC1 with a 180kΩ resistor. The changes to T1 involve using 130 turns on the secondary. For the primary use figure-8 7.5A wire with a polarity stripe. Insert one end of the figure-8 wire in the S1 & F1 holes nearest to Q2 and wind on five turns, starting up through the centre of the core and anticlockwise towards S2 & F2. Insert the wire ends into S2 & F2 with continuity (same wire) between S1 and S2 and the second wire between F1 and F2. This means that if the polarity stripe on the figure-8 wire is at S1, it then terminates into S2.

Set the current drain from the battery at 3A (300mV across the 0.1W resistor used in the current measurement set-up in Fig.8). As noted in December 2002, it is recommended that the maximum current delivered to the fluorescent tube be adjusted using a trimpot. The 100kΩ resistor connecting between pin 2 of IC3 and the top of the dimming potentiometer (VR1) should be replaced with a 50kΩ trimpot and series 82kΩ resistor. The 1.2Ω resistor between the source of Q4 and ground should be changed to 2.2Ω to allow the full dimming range available from VR1.

Using the current measuring setup of Fig.8, the trimpot should be adjusted for the 300mV, corresponding to 3A when the dimming pot (VR1) is turned fully clockwise. Note that this adjustment should be made after the inverter has been running for some time and is fully warmed up. Once adjusted, the trimpot and 82kΩ resistor can be swapped for a single resistor that is the same value as the total series combination.

When testing the current (using the setup of Fig.8), it is important not to have the 0.1Ω 5W resistor in series with the supply for any appreciable length of time as the current drain will begin to increase. To prevent this, short out the 0.1Ω resistor (with a clip lead) when not making the measurement. Remove the clip lead briefly to make the current measurement.

In addition, use heavy gauge wire rated at 7.5A or more to connect the inverter to the 12V battery.

It is recommended that the inverter not be used while the battery is being charged from a high current charger such as an automotive alternator or mains-powered unit.

If the inverter Mosfets still run excessively hot, it is recommended to reduce the current drain to 2.5A (250mV across the 0.1Ω resistor) which will reduce the lamp brightness slightly.

With slimline batten holders, ventilation can be improved by drilling some holes in the side of the batten adjacent to the Q1 and Q2 heatsinks and some extra holes at the other end of the batten to allow air flow. **SC**

rent rating of more the than load current being switched. This should suppress any contact arcing across the relay contacts.

When switching 240VAC with a solenoid, it is usual to connect a 250VAC-rated capacitor across the (solenoid) contacts. Try a 47nF (.047μF) 250VAC capacitor across the contacts.

High input impedance amplifier wanted

I would like a suggestion for a high input impedance amplifier circuit. What I need is to be able to intercept a line level signal and basically split it in to two line level signals. I need it high impedance so that it doesn't load the line too much.

I want to build five of these amplifiers and then use them to provide line-level outputs from each channel of my Boston Acoustics BA7500G Speaker system so I can feed external amps, without disturbing the internal amplifier. Any help would be greatly appreciated. (M. R., via email).

● You really don't need a high input impedance. What you need is a buffer amplifier that can drive a series of low impedance outputs. We have already published a suitable circuit – the audio portion of the Audio/Video Distribution Amplifier in November 2001. This circuit is based on an LM833 dual op amp.

If you decide to use it, make sure you install 1kΩ resistors in the outputs instead of the 47kΩ resistors mistakenly specified in the original article.

Speed control in cordless drills

I recently bought a variable speed cordless drill/screwdriver (Black & Decker) and would like to know what method is used to provide the variable speed feature. I guess I could open the drill and look inside but that will void my warranty. (H. P., via email).

● Cordless drills are usually permanent magnet motors with a Mosfet switchmode power control, usually running at about 1kHz or so. In fact, you can usually hear the 1kHz tone at very low speed settings.

Temperature controlled fan

I want a circuit for a temperature-controlled fan for the heatsinks of an amplifier I'm working on. I am positive SILICON CHIP published one in the not-too-distant past but for the life of me I can't find it in my back issues, nor can I locate it on your website. Can you recall where the circuit appeared please? (G. B., Scotland Island, NSW).

● The circuit was associated with the Ultra-LD Amplifier in the August 2000 issue. There were two options: a thermistor or thermal cutout. **SC**

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